The Aeroplane and Astronautics
FEBRUARY 12, 1960

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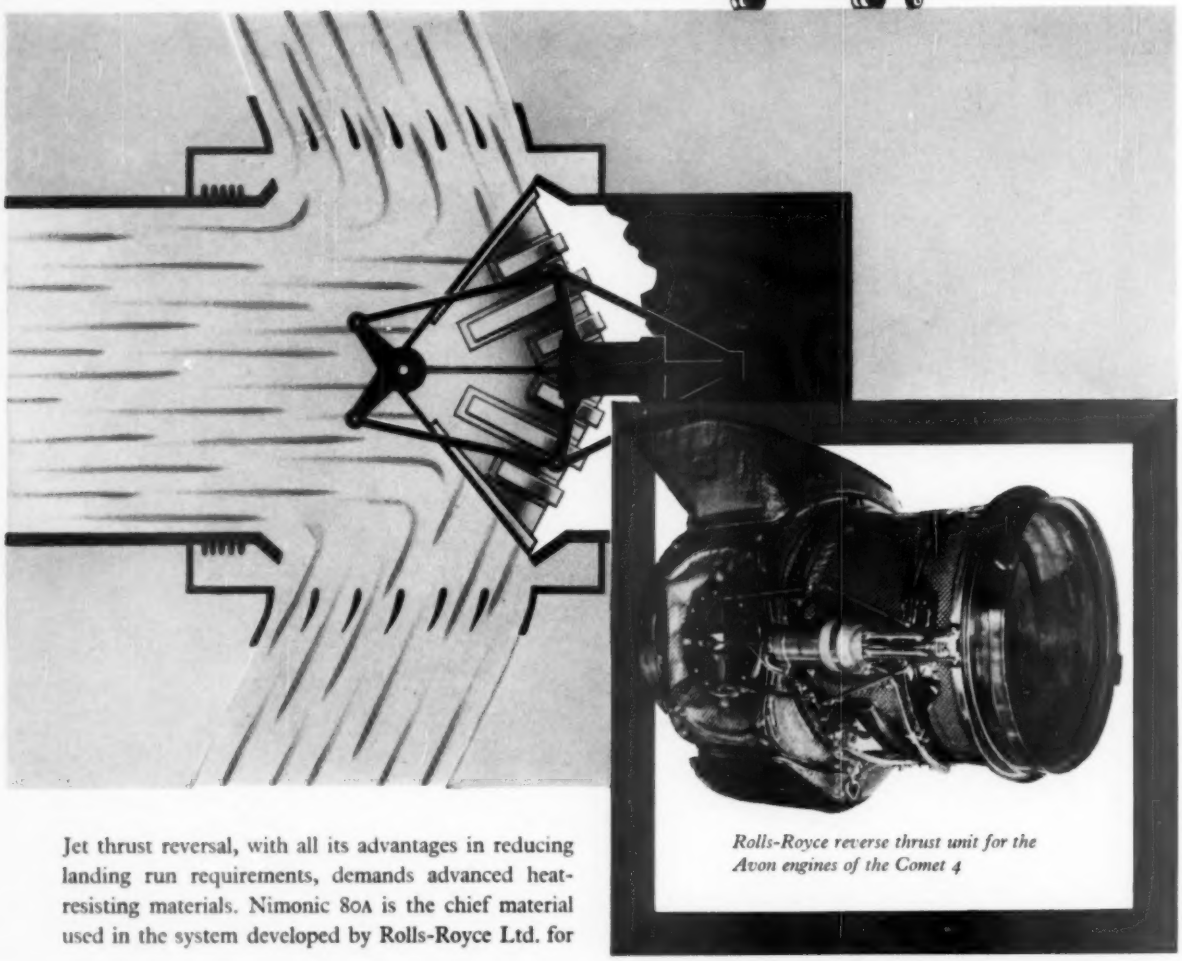

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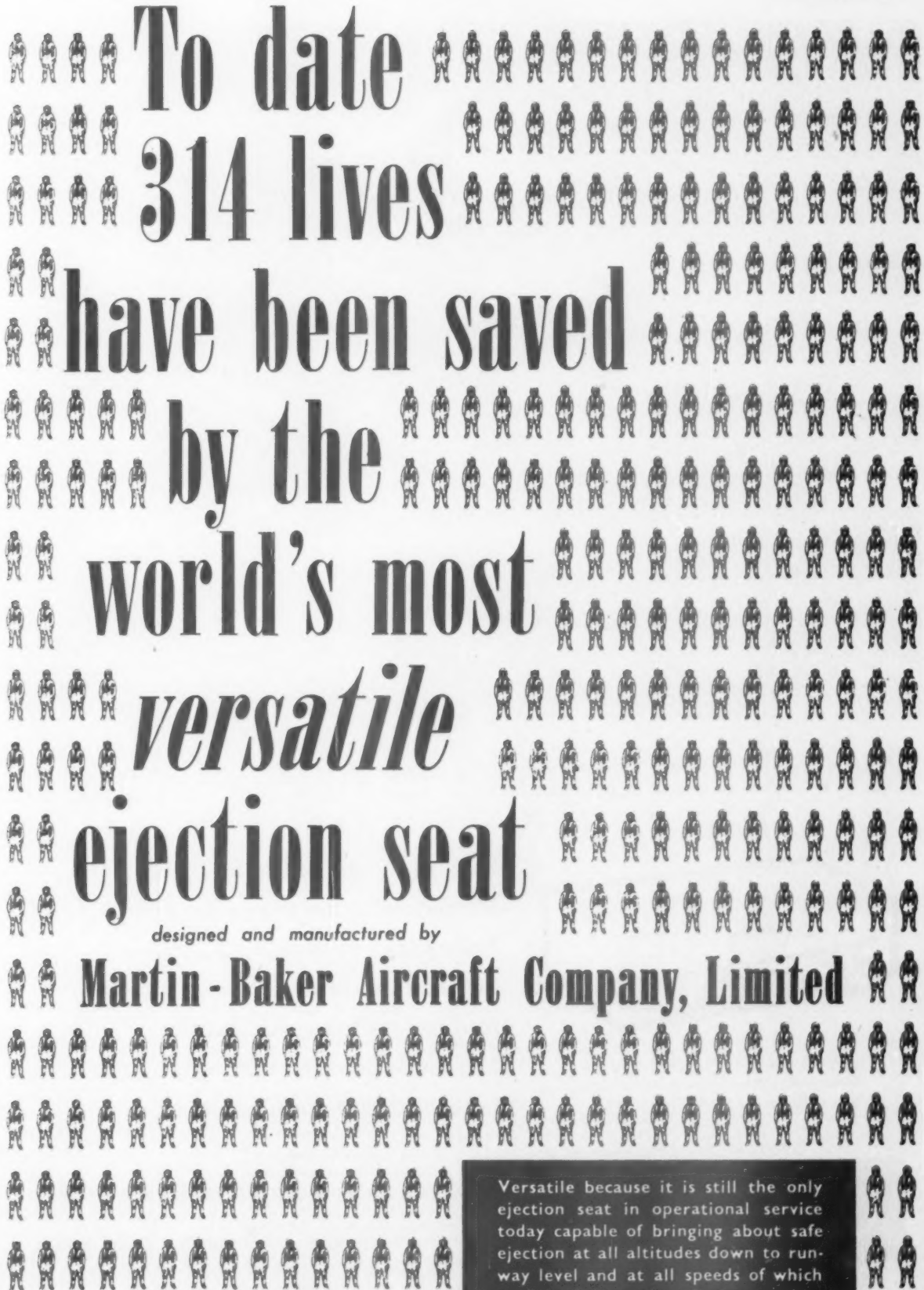

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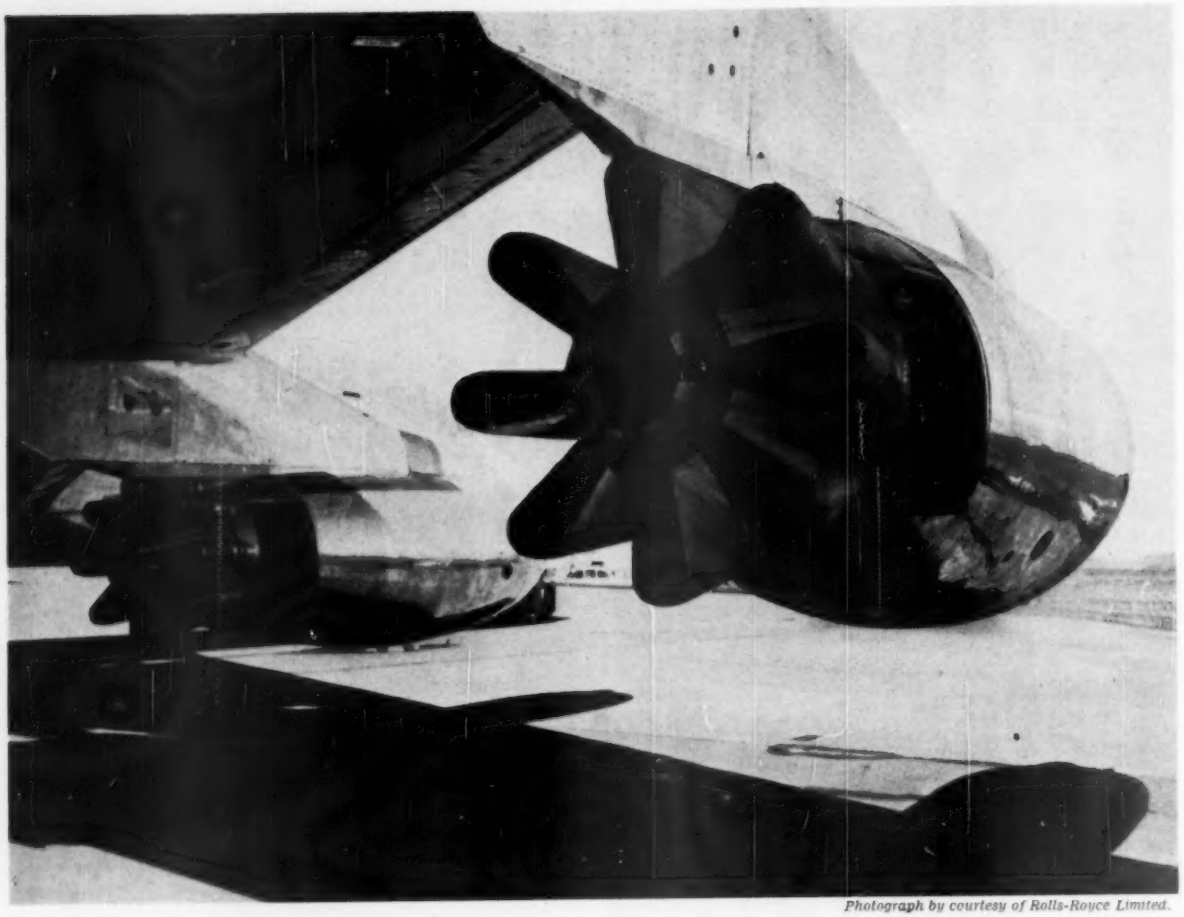

Photograph by courtesy of Rolls-Royce Limited.

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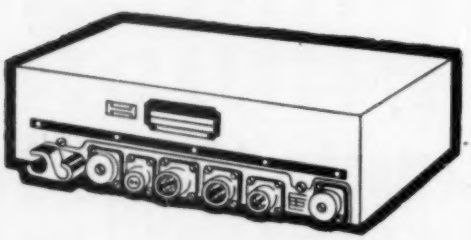

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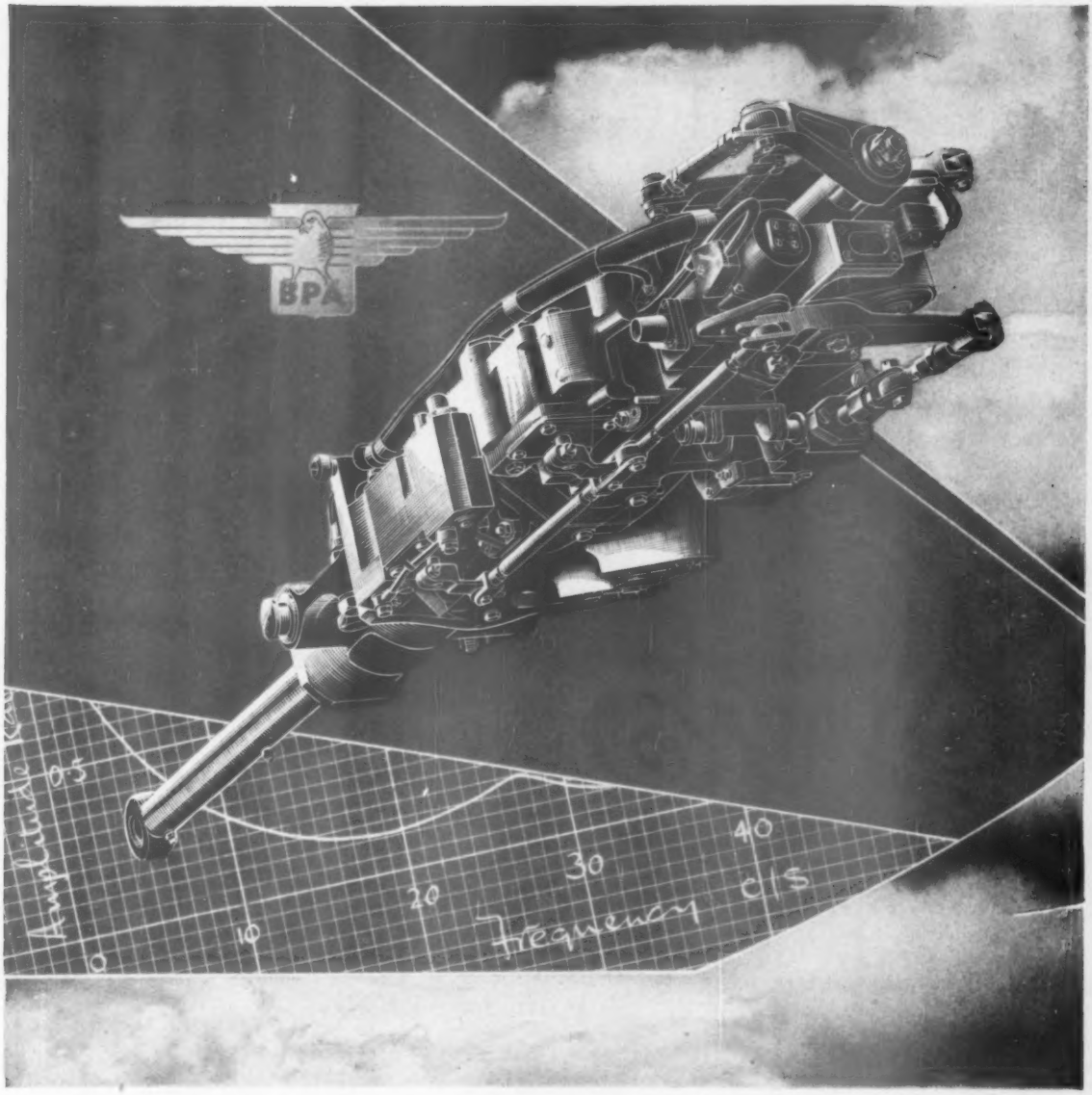

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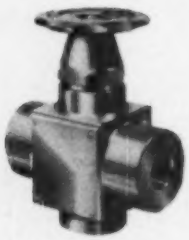

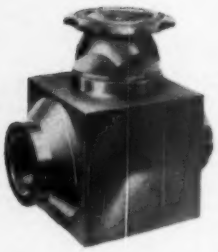

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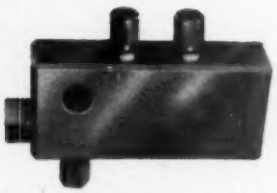

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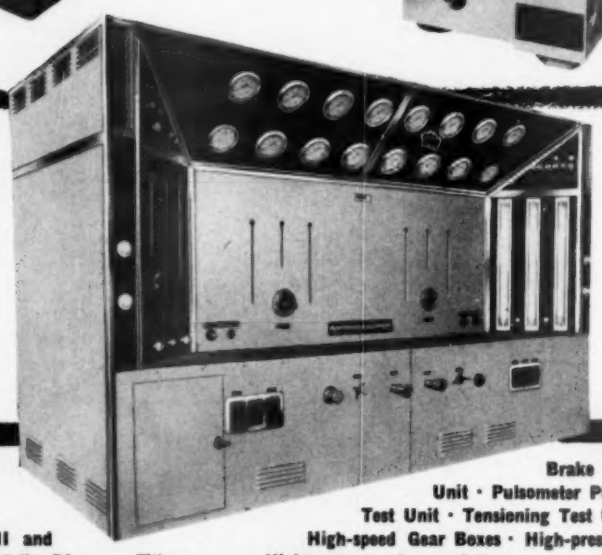

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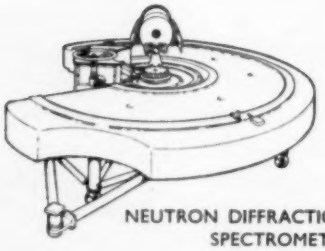

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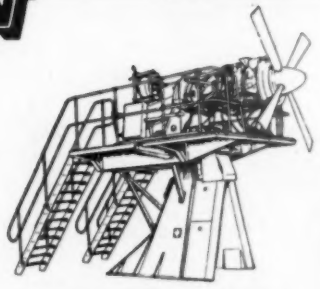

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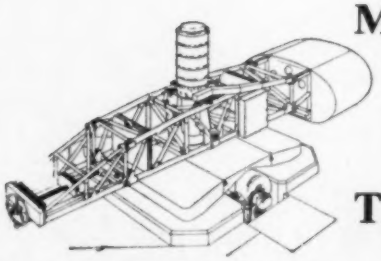

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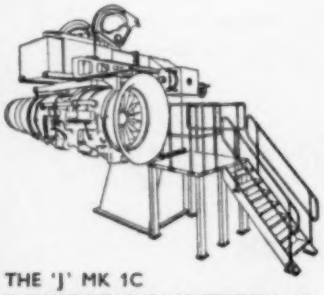

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THE AEROPLANE and ASTRONAUTICS

VOLUME 98 NUMBER 2521 FEBRUARY 12, 1960

Latin American Developments

Despite pessimistic forecasts of traffic prospects over such a competitive route, the importance of B.O.A.C.'s re-opened South American service has been underlined by the fact that the Minister of Aviation travelled on the inaugural Comet and stayed behind to discuss air transport and other matters of mutual aviation interest. He visited the new Rolls-Royce aero-engine factory at Sao Paulo. He discussed, too, it is said, the possibility of a Brazilian subsidiary of the British aircraft industry being established to build the Avro 748, constructional features of which are described in this issue.

His discussions included the terms of a revised Anglo-Argentine air services agreement, which was originally signed in 1946 during the more benevolent development period of air transport and which included rights to carry traffic between Argentina and neighbouring countries. Since the days when B.O.A.C. discontinued its South American services (in 1954) the attitude towards such fifth-freedom rights has hardened and a quota system has, in the meantime, been instituted for other carriers operating through Buenos Aires.

No one will be surprised if fifth-freedom rights, in this area and elsewhere on the route, can be obtained only at the price of end-to-end revenue-pooling agreements between B.O.A.C. and the national operators to and from Europe—Aerolineas Argentinas and Panair do Brasil. Meanwhile, as we go to press, we learn that Brazil has provisionally lifted the fifth-freedom restrictions on sector traffic between Lisbon and Brazil.

Women in Aviation

No man likes to contemplate opening the smoking room of his club or the bar to women members. Having said this, let us first make it clear that we do not suffer from an anti-woman complex. Indeed it seems to us that in these enlightened days it may well be argued that the Royal Aero Club continues to be excessively anti-feminine. One might think that there are no women in aviation at all. This may stem from the long-standing S.B.A.C. veto on women guests at the non-public days at Farnborough, or it may just be conservatism.

The matter was brought to mind at the splendid film show at the Soviet Embassy on the evening of February 3. Ironically enough this came about from the enterprise of the Secretary General of the Royal Aero Club, Colonel Preston. It was he who asked his Russian hosts some months ago for a copy of the film showing the splendid performance put on by the Central Flying Club of All the Soviets.

Quite apart from the skill of the individual performers, this Russian film is outstanding for its portrayal of aerobatic teams of pilots and parachutists alike. Few people who saw the film are likely to forget the sight of a glider hanging like a slung fish from the end of its tow-rope hundreds of feet above Tushino airport.

Anyway, to come back to the women, the Russian film would have lost much of its impact without them, whether as parachutists or pilots of aerobatic teams. We too have women parachutists and women pilots and women engineers. On this occasion there was one woman only present, and she a journalist (who obtained her gliding "C" licence in 1956).

If the part that women played in sporting flying was better appreciated, it would never occur to organizers to exclude them on such occasions. Can it be that British aviation is still regarded as a masculine prerogative?

Editor - - - - - THURSTAN JAMES
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Matters of Moment

No Damp Squib

PEOPLE with some sense of responsibility will certainly have been startled to learn on the authority of one of our most highly regarded daily newspapers that Blue Streak, the long-range ballistic missile on which so much technical expertise has been lavished by de Havilland Propellers, by Rolls-Royce and by Sperry is nothing but a damp squib. The conjunction of the diminutive squib with the imposing magnitude of the three-yard (as one might guess) diameter rocket may be effective as a piece of headline writing but can scarcely be regarded as a responsible comparison. We are quite sure that no one connected with the publication of the article would be prepared to go within 300 yards of Blue Streak on its launching pad at Woomera.

Let us hope that the article in question does not cause anyone to think that the engineers involved with the design and construction of this advanced weapon have boobed. There is no question at all of the performance of the missile falling below expectation. What has happened is that the planners, bless their blissful uncertain minds, are beginning to wonder whether a bird in the bush, or even alleged to be about to be airborne, may be better than the bird actually in hand in the launching tower.

In addition, there is a widespread point of view that the latest version of the airborne deterrent, the nuclear warhead carried by a missile launched from an aeroplane, has various advantages of mobility that even outweigh those possessed by the submarine-launched Polaris. But such a weapon has yet to be developed.

Once again we are faced by the better being the enemy of the good. This situation has been the curse of British aviation before, when an official decision has been taken to scrap something on the eve of its completion because eventually something else, which has yet to be designed—much less built—is going to be so much better.

It might be relevant here to recall the Vickers V.1000 and the Avro supersonic bomber; the last mentioned would have put us within reach of the supersonic airliner.

While the arguments are raging about Blue Streak we trust that there are those at the appropriately high level who are drawing the attention of all concerned, not least the Treasury, to such facts of life as the certainty that man is on the verge of moving out into space. We have been so backward in this field that the successful development of Blue Streak remains the only hope of this country, and indeed of the whole vast Commonwealth of which it now claims to be a unit rather than the leader, of taking part in the necessary experimental activities. What a pity that so many otherwise decent people seem set on making this country thoroughly second-rate.

What is Skybolt?

SUGGESTIONS have been made that Britain is considering the adoption of the U.S. Skybolt air-launched ballistic missile as a deterrent weapon. It has even been said that this might be chosen in preference to the Blue Streak LRBM.

At present Skybolt is being developed by Douglas for the U.S. Strategic Air Command; its designation is XGAM-87A. Douglas was chosen as prime contractor after a design competition involving more than a dozen companies during 1958-59. Earlier ALBM test vehicles have been produced by Lockheed and Martin.

Skybolt is a relatively small ballistic missile which will be carried by B-52 and B-58 bombers. Reports suggest that it is designed for a ballistic range of up to 1,000 miles after being toss-launched from the carrier aircraft at an angle of about 45°.

The missile is powered by a solid-propellent Aerojet rocket motor fitted with "jetavator" deflectors of the kind developed for Polaris. Its inertial guidance system is being supplied by Northrop's Nortronics Division. An ablative nose-cone is being developed by General Electric to carry the nuclear warhead.

Gen. Le May, vice-chief of staff of the U.S.A.F., has said that the Skybolt can be launched from aircraft flying above or below Mach 1. But clearly this weapon becomes more difficult to counter the faster the aircraft from which it is launched. The most advanced U.S. projects, the M=3 B-70 bomber and the nuclear-powered bomber, would both be armed with ALBMs.

Skybolt represents a logical development beyond stand-off bombs such as the Hound Dog of the U.S.A.F. and the British Blue Steel, which recently began its flight tests. Advantages of the ALBM are its greater range and its higher speed, which make it much more difficult to intercept. To some extent the missile will only be as effective as its carrier aircraft, particularly if attacks are to be made on targets deep in the enemy territory.

There is no inclination in the U.S. to regard ALBMs and ICBMs as competitive weapons; they are complementary parts of the total nuclear deterrent. The bases from which Skybolt carrier aircraft operate will be much more vulnerable to missile attack than hardened LRBM sites, until the infinitely long-range nuclear-powered bomber arrives.

IN THE NEWS.

Top left, Mr. V. C. Varcoe, O.B.E., the new Clerk to GAPAN. Above, Mr. J. Boyd Carpenter, M.P., Minister of Pensions, speaking at lunch following the opening of the new Cellon Laboratory; on his left, is Mr. J. D. Ferguson, chairman of Cellon. Extreme left, Dr. M. J. Lighthill, director of R.A.E., addresses R.A.E. apprentices at their 15th prize distribution; on his right is Sir Owen Wansbrough-Jones and, on his left, the retiring principal Mr. R. D. Peggs. Left, Prof. Alla G. Masevich, who lectured to the B.I.S. on February 10.

Parent of the Industry

REAR-ADMIRAL Sir Murray Sueter, C.B., who died last week at Watlington, Oxfordshire, aged 87, has been widely regarded, and rightly, as the father of British Naval Aviation. He might well be regarded as one of the parents of the British aircraft industry too. It was Naval support for the private venturers which enabled the founding firms, Shorts, Fairey and Sopwiths, to reach the positions of strength whence they met the inescapable demands of all-out war for supreme fighting machines. Equally, it was the Naval support for private venture which brought into availability the engines that the Royal Flying Corps demanded in their hour of trial.

It is a matter of history that the demand for a "bloody paralyser" put forward by the then Captain Sueter from Mr. Frederick Handley Page resulted in the Handley Page O/400 and its successors.

Murray Fraser Sueter, born in 1872, went to sea in the Royal Navy in 1888. He was involved in early wireless trials and submarine development.

He was promoted Captain in 1909 and one year later appointed to the new post of Inspecting Captain of Airships. In 1912 he was made director of the new Air Department of the Admiralty. When an officer of flag rank was appointed Director of Air Services in 1915 Commodore Sueter became Superintendent of Air Construction. In his own words he was later "banished" to command R.N.A.S. units in Southern Italy, actually at Taranto.

He retired as Rear-Admiral in 1920 and became M.P. for Hertford from 1921 until the general election of 1945.

He played a considerable part in the development of the Empire Air Mail scheme.

He was appointed C.B. in 1914 and knighted in 1934.

Rotary-wing Leadership

ACQUISITION of Fairey Aviation, Ltd., by Westland Aircraft, Ltd., was announced on February 3. The former company is a subsidiary formed last year by the Fairey Company which in turn sprang from the Fairey Aviation Co., Ltd., which the great Sir Richard Fairey had founded when he left Short Brothers to set up on his own in the early days of World War I. Reaction in the City to the deal was a rise in the value of Fairey shares.

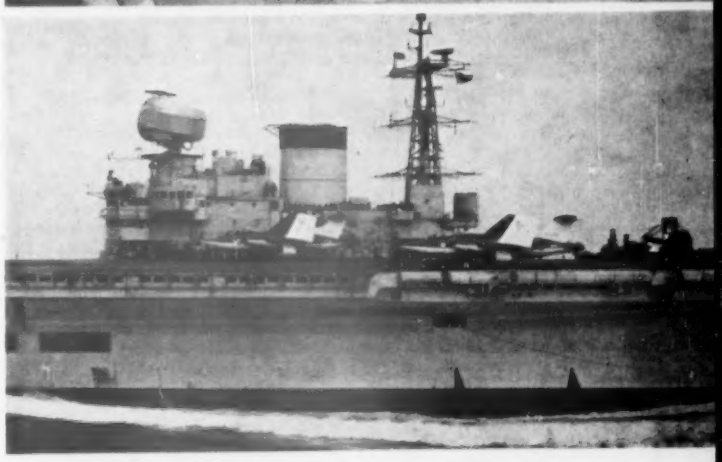
The subsidiary, bought by the Westland Company, controls all the aviation activities of the Fairey Group in the United Kingdom. Fairey's non-aviation activities are controlled through other subsidiary companies. By the acquisition of Fairey Aviation, Ltd., for a price around £3.3m. the Westland Company acquires the Fairey Gannet, work being done on the Fairey FD-2 research delta and the Fairey Rotodyne.

The Westland Company has not taken over the Fairey aircraft interests in Belgium, as represented by Avions Fairey at Gosselies which is expecting to get a contract in connection with the ordering of Lockheed F-104 fighters for the Belgian Air Force. The latter produces Tipsy designs such as the Nipper. The Fairey Aviation Co. of Canada, Ltd., and the Fairey Aviation Co. of Australasia Pty., Ltd., will continue their activities as part of the Fairey Group. Also the Fairey Company remains in the guided weapon business with work on an unnamed military weapon and with Jindivik production in Australia. It will also continue with the production of power controls so widely used in international aviation.

Unlike the other aviation combinations where the first indications have been that the individual identities of the concerns are being preserved, in this instance Westland Aircraft, Ltd., which is a comparative newcomer in so far as its association with the great John Brown organization is concerned (it was formed in 1935), is to carry through a policy of integration, which will result in all the acquired designs and developments being produced under the Westland name. Exactly how the various design teams are to be integrated under their various leaders has yet to become clear.

Westlands have now become the sole producer of rotary-wing aircraft in the country. Its products range from the two-seat Skeeter, through the Wasp, the five-seater P.531 helicopter, through the Bristol 192 tandem-rotor machine, now in production, through the various well-known Westland designs, at least two of which are confidently expected to receive further military orders including the turbine-engined Wessex, to the uniquely gigantic Rotodyne.

The premier position, not only in the U.K. but internationally, now achieved by Westland Aircraft as a result of the various combinations can now be seen as the culmination of a policy which might be regarded as starting with the formation of the company, for it was as long ago as 1935 that the Company was flying a two-seat cabin Autogiro of its own design. Today their latest acquisition may be regarded as a logical extension of Cierva's original work.



SEA TRIALS.—Successful deck-landing trials with the NA.39 (two Gyron Juniors) were recently concluded aboard H.M.S. "Victorious." Two aircraft were involved.

Westlands' plans for the Rotodyne are being awaited with deep interest. As Mr. Sandys has announced in the House they have assured him of their intention to proceed with the £4,000,000 development contract. The prototype, modified with a third, central fin and streamlined head to the rotor is flying again.

At the time of the take-over, orders for five from New York Airways, for one from Okanagan Helicopters and a letter of interest for six from B.E.A. had been announced. It is also known that the Army want a number.

An aspect of the Westland company's activities worthy of note has been the close liaison established with the Napier Company whose products power the Wessex and Westminster as well as the prototype Rotodyne. Napier Gazelle turbines also power the Bristol 192 now in production. This substantial utilization of Napier products could only be enhanced if it were decided to follow the Napier-engined prototype of the Rotodyne with more Rotodynes of the same mark. Such a decision would get the Rotodyne more quickly into service.

Transport Command Prospects

THIS year's Brancker Memorial lecture presented some authoritative views on the nature and future of British military air transport. These were given by Air Marshal Sir Denis H. F. Barnett, K.C.B., C.B.E., D.F.C., A.O.C.-in-C. Transport Command.

He suggested that substantial expansion was needed in the number and types of short-range transport available for "the more intimate form of support of fighting troops in forward areas of engagement." Because this category of aircraft was at present small, this expansion was needed more than in the case of any other class of aircraft.

So far as the long-range end of the scale was concerned he reiterated his conviction that our prime continuing need was for really high and progressively contemporary performance in at least an element of our strategic fleet.

"For example," he said, "if one peers ahead no further than the already contemporary Comet 4 and the almost contemporary VC.10, the current times of execution, which now are measured in days, become measurable in hours. Two equipped battalions could be delivered to the Arabian Peninsula in a morning."

British Lightplanes

FROM Portugal come details of a new range of light aircraft, by the Auster company at Rearsby, in which the Portuguese Air Force is apparently interested. The Government-owned General Aeronautical Material Workshops (O.G.M.A.), which since 1920 has built training aircraft (including 91 Tiger Moths and 56 Chipmunks) under licence, is seeking three new types for production, comprising a jet trainer, a small transport and a light aircraft.

The last-named is required for club, training and general operations, and 170 of the new Austers have apparently been recommended. Two variants have been mentioned; both are modernized versions of the well-known Auster high-wing configuration, with its tailwheel undercarriage, and appear to be generally similar, except for accommodation and powerplant.

The Auster D.4 is a two-seater powered by a 108-h.p. Lycoming engine, and is mainly intended for club use in Portugal. It is credited with a maximum speed of 142 m.p.h., a cruising speed of 103 m.p.h., and a stalling speed of 30 m.p.h. Range is said to be 298 miles and landing distance, 298 ft.

The second variant, the J.1Y, is a three-seat general-purpose type, with a 160 b.h.p. Lycoming, intended for agricultural use, with a 100-gal. chemical tank on the starboard side of the cabin, as an alternative to the normal passenger load. Its military potential includes A.O.P. and ambulance duties. Take-off run, at 360 ft., is reportedly the same as the D.4, but the landing distance is 373 ft. Maximum speed is estimated at 136 m.p.h., cruising speed as 113 m.p.h. and stalling speed, 33 m.p.h. Range is 481 miles.

R.Ae.C. Races and Rallies

SOME welcome changes are apparent in this year's National Air Race programme, which is still awaiting finalization by the Royal Aero Club, but is already confirmed as taking place at several different meetings. This year sees the reintroduction of an air touring competition, of the type so popular in pre-war days, and now made possible by the influx of new aircraft into this country. The programme also includes a cross-country air race.

The Business and Touring Aircraft Competition is to be held over the week-end of May 20-21 at Shoreham, and will involve a circular flight of approximately 450 miles with provisional turning points at Filton, Fakenham, and Lympne. There will be three classes of entries, by seating capability, weight and powerplants, and while the precise formula by which the competition will be judged has not yet been announced, take-off and landing performance and ground manœuvrability will be assessed on the second day of the meeting.

Last held in September, 1938, a London-Cardiff air race is taking place on June 3-4. This will probably be from White Waltham, on Friday, June 3, terminating at Rhoose, where short circuit races will be held the following day. These events, for the existing R.Ae.C. trophies, will qualify competitors for the King's Cup Race, and some discussion is taking place on the possibility of including, for the first time, foreign aircraft in the latter contest.

With the Lockheed International Aerobatic Competition, the King's Cup will be competed for at Baginton, Coventry, on July 8-9, over the traditional circuit. Twenty-one aircraft will be eligible to compete, comprising the first seven in each class.

In addition to these major events, a small display of executive aircraft and equipment is being organized, in conjunction with the B.A.R.C., at Goodwood on Easter Monday, April 18. Most of the executive aircraft types now available in this country will be represented, and by way of nostalgic interlude flight demonstrations will include the familiar tail-chasing performance by the Spitfire and Hurricane.

Fantastic Weapons

A CORRESPONDENT has pointed out that in our January 22 issue and again on page 143 of the January 29 issue we referred to Mr. Khrushchev's recent speech about "the fantastic new weapon."

He has not seen an official TASS English handout on this, but after examining the text in *Sovietskaya Aviatsiya* believes that Mr. Khrushchev was not referring to a particular weapon.

The word used is *Opyskve*—a singular noun often used with a plural meaning, e.g., if one wants to talk in Russian about the banning of nuclear and/or atomic weapons—as Mr. Khrushchev did—you say "No banning of the nuclear weapo*n*" (singular). If you translate Mr. Khrushchev literally, the result is: "The weapo*n* which we now have *is* terrible, but that which *is* about to come out, which *is* in the brief cases of the scientists and constructor*s* is more terrible."

Our correspondent suggests the correct translation of Mr. Khrushchev's words to be:—

"The weapon*s* which we have now *are* terrible, but those which *are* about to come out, which *are* in the brief cases of the scientists and constructor*s are* more terrible."

And similar remarks could be made by at least two other international figures with equal accuracy. The point made by our correspondent seems worth study.

Report on Civil Aviation

PUBLISHED by the Bow Group of the Conservative Party, "Wings Over Westminster" has apparently been rather rushed into print although it has been worked on for some time. It could have done with some polishing.

It is a good little history in 17 chapters of the vicissitudes of British Civil Aviation over the past 40 years. It is a good thing to have it all together without too much passion and dealing with nearly every aspect.

Only the knowledgeable reader will grunt now and then at certain touches of the amateur, some inconsistencies and a number of very arguable statements. But if it had not been for these last, it would have been slightly dull.

It starts with 20 questions, and in the reply to one of them it says that B.O.A.C. and B.E.A. are completely free of subsidy. There must be some technical trick hereabouts in differentiating between kinds of losses.

The chapter on the Financial Fortunes of the Airline Industry, the problem being dealt with: "What of the immediate future?" is so fouled up with unknowns that the words and figures mean very little. Some of the conclusions based on the Corporations' rather too detailed annual reports lead one to wonder whether it is the figures themselves, or how they are used, that leads one astray.

No doubt inconsistencies such as saying in one place that the Corporations suffer from difficult financing conditions, having to pay interest whether making money or not, and in another place saying that their financing arrangements are favourable, will disappear with revision. So would the mention of *petrol* being poured into the Vanguard.

There is a great deal about the necessity for low fares for mass travel. It is by no means clearly stated that the scope for the sub-economy fares to the Commonwealth must diminish year by year as the colonies become independent, form their own airlines and join IATA.

The future of mass air travel outside the U.K. lies in hard work within IATA, in careful planning, co-operation with other airlines and grinding away at our costs and their costs. Then one day we shall have mass travel and we may never realize just when it happened.

There is a lot about the low cost of the Independent airlines. The report leaves one with a feeling that there is some mystery about these costs. There is a mystery, but it is not what is implied, which is that they may have "got something." It is merely that they do not give enough data so that they may be compared properly with B.O.A.C. and B.E.A.

It is stated that "the very small airlines can operate at very low costs." So do big airlines, and at a given level of operation at lower costs than the little man. It must never be forgotten that at a given fatality rate a small airline may fly for 10 years with no fatalities, whereas the 10 times larger airline would have one every year. To be comparable in the public mind, the large airline has to be much better than the small one.

About the desirability of having a lot of Independents or only a few (merged) the report seems at odds with its chapters. Politically it obviously wants a lot of them, but practically cannot quite see how it works. Not much attention seems to have been paid to the fact that most countries have only one international operator. We have 2*, U.S.A. 2 in Europe, France has 1½, getting on for 2. It is difficult enough with 2. With some of the more skilled countries (in negotiating) it would be a field day if we made any serious attempt to triple or quadruple our operators. Most regrettable.

In the chapter on Management and Morale the problems of Trade Unions are discussed and the effect of them on morale. This chapter is well done, except for the complete omission of perhaps the greatest union activity in morale-reduction, that of the aircrew. Many people feel now that the pilots are trying to take gross advantage of their position.

In the wordage allotted to these remarks, it is not possible to comment on all the chapters of this interesting report. It requires nothing to be added except a little more knowledge.

EGON MURRAY.

* If we can for a moment just forget the Independents.

Aviation News in General

MISSILE BOMBER.—An artist's impression of the turbofan B-52H missile bomber for SAC. The B-52H is illustrated here with North American Hound Dog AGMs and rocket-firing pods described as "target penetration aids."

OSTIV AT COLOGNE.—Once again the Congress of OSTIV, which is the International Organization for the Technical and Scientific Aspects of Motorless Flight, is to take place concurrently with the World Gliding Championships. These are being held in Germany at Butzweiler airfield, just outside Cologne. This, the eighth Congress, will be open in that city at 11 a.m. on Tuesday, June 7. Technical sessions will be at Butzweiler from June 7-11. There will be general conference, June 14; meteorological session, June 15, 16, 17. Selection of best standard-class sailplane will again be done by jury of pilots.

ITALIAN F-104s.—It is expected that Italy will purchase Lockheed F-104G Starfighters to re-equip its fighter squadrons. Proposals are reported to be under way to buy West German-built F-104Gs through an exchange with certain Italian aircraft. F-104Gs may also be obtained from the United States.

GAN AIRFIELD.—An agreement has now been concluded between the British and Maldivian Governments under which the U.K. receives the free use of Gan airfield for 30 years. Approximately £4 million has been spent on the R.A.F. staging post and the U.K. has agreed to make a direct grant to the Maldives of £100,000 and provide a further £750,000 spread over a period of years.

SKI HERCULES.—Versions of the Lockheed Hercules equipped with 20.5-ft.-long skis in addition to wheels for multi-terrain operation, are designated C-130D; twelve have been ordered. With 3,750 e.s.h.p. Allison T56-A-9 turboprops, the C-130D will carry a 31,000-lb. payload for 1,500 st. miles or 10,000 lb. for 3,240 st. miles, at 335 m.p.h. Seven C-130Ds in operation "Deep Freeze 60," for landings at the South Pole, have eight 1,000-lb. JATO bottles for heavy take-offs. Normal take-off distance to 50 ft. on skis at 120,000 lb. is 3,300 ft.

A NEW TUPOLEV.—A Polish report describes a new medium-range Russian airliner, the Tupolev Tu-124, as being in an advanced stage of construction. The engines are said to be designed by Soloviev.

HEAVIER VANGUARD.—Maximum take-off weight of the Vickers Vanguard has been increased, in the standard specification of the aircraft, to 146,500 lb. Further substantial increases in the landing and zero fuel weights are expected to be announced shortly.

TOP DROP.—An aircraft of the U.S. Air Force successfully dropped a one-ton Mercury capsule from 31,000 ft. into the Salton Sea, California, on January 30. Previous descents—all successful—have been made from 2,000 to 30,000 ft.

SCIMITAR EJECTION.—A low-altitude ejection was successfully made at Lossiemouth on February 6 by a Scimitar pilot of the Royal Navy. The escape, with the aid of a Martin-Baker Mk. 4C automatic ejection-seat, was made on the landing approach after the pilot had transmitted a warning of "technical difficulties."

ASTRONAUTICS IN TOKYO.—The Japanese Rocket Society are holding their Second (1960) International Symposium on Rockets and Astronautics in Tokyo from May 24-28. An international programme of lectures includes several from the United States.

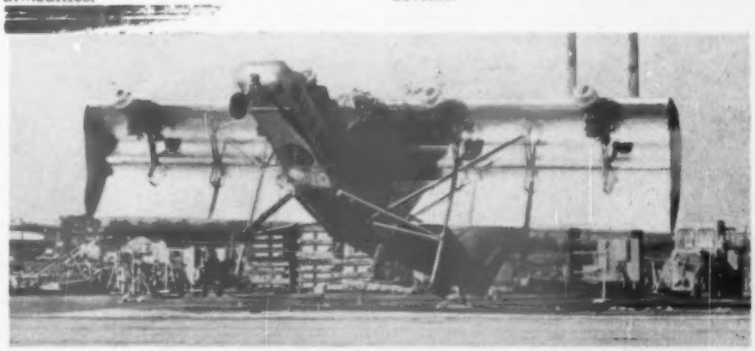
ORBITAL X-15?—A two-man orbital version of the X-15 high-speed, high-altitude, research aircraft has been projected by North American Aviation as a possible rival to Dyna-Soar. No change of dimensions or configuration is envisaged beyond the provision of external propellent tanks and retro-rockets, but there would be a new "high temperature structure." Launching vehicle would be a two-stage Saturn.

DISCOVERER IX. — The ninth Discoverer satellite launched from Vandenberg on February 4 failed to orbit. A 300-lb. capsule was intended to eject automatically on the 17th orbit and return to Earth by parachute. Release of aluminium chaff would have accompanied parachute deployment to assist radar location.

TRANSPORT CONGRESS. — The 1960 Congress of the Institute of Transport will be opened by the Minister of Transport on April 27, at the Waldorf Hotel. On April 28 at 11.00 hrs. Mr. Peter Masefield will present a paper entitled "British transport aeronautics—looking ahead."

UP ALOFT.—Launched from the U.S. aircraft carrier, "Valley Forge," a giant balloon of 10,000,000 cu. ft. capacity recently carried 1,600 lb. of research instruments to an altitude of nearly 22 miles. Object was to gather cosmic ray data.

BOOSTS AND ORBITERS.—A new Aerospace Technology Department, with more than a dozen scientists and engineers, has been set up by Lockheed Aircraft Corp. Studies will include hypersonic ram-jet aircraft, boost-glide missiles, orbital vehicles, and re-entry devices.



FAIRCHILD VTOL.—Tied-down hovering tests have been made with the Fairchild VZ-5FA VTOL/STOL experimental aircraft which is being developed for the U.S. Army, and it is now undergoing full-scale wind-tunnel tests.

Howard Levy photographs

Commercial Aviation Affairs

CONVAIR VARIANT.—Newest variant of the Convair 880 family—the Model 22M—is in production for Capital Airlines (seven) and Civil Air Transport of Formosa (one). To be powered by 11,650-lb.s.t. General Electric CJ805-3B turbojets, it will have the power-boosted rudder of the Convair 600 and leading-edge slats. Stalling speed will be reduced from 113 m.p.h. to 106 m.p.h. All weights are a little higher than those of the basic Model 22—max. take-off 191,000 lb.; max. landing, 155,000 lb.; and max. zero fuel, 121,500 lb.

INDEPENDENT EQUIPMENT.—Recent applications to the A.T.A.C. for scheduled service rights by various independent operators indicate some of their intentions—or hopes—so far as future equipment is concerned. Thus, Orion Airways have mentioned Viscounts and Avro 748s in their applications, Derby Aviation lists Dart Heralds and Viscounts, and Don Everall (Aviation) is seeking all-freight rights using DC-3s or Bristol 170s.

LOT PLANS.—Poland's national airline, LOT, plans to buy a fleet of Ilyushin Il-18s, with the first three to be delivered this year. This plan follows unsuccessful attempts by LOT to buy Viscounts or Caravelles. Services from Warsaw to Rome via Vienna and to Tel Aviv via Athens are to be opened by LOT this year.

FRENCH CIRCUIT.—Air France will open its Boeing 707 service to Los Angeles (via Montreal) on April 2, taking advantage of the recently concluded agreements with the U.S. Government. T.A.I.'s plans to complete an all-French World circuit by extending its Pacific service to Los Angeles have been complicated by the breakdown of Australian-French discussions, but the company hopes to inaugurate a DC-6 service from Bora Bora or Tahiti to Los Angeles in May.

SUPER CONVAIR ORDER.—Lake Central Airlines signed a contract on January 22 for five Allison 501-powered Super Convair turbojet conversions, with an option on 10 more. The order is the first from an airline for the Allison-powered conversion, the first of which is to fly shortly. Deliveries will be made in the autumn of this year, and conversions will be made by PacAero.

CRASH INQUIRY.—A B.U.P. report from Washington suggests that two of the engines of the Capital Airlines Viscount which crashed in Virginia on January 18 were stopped and the propellers feathered at the moment of impact. The other two propellers were reported to be in "flight fine pitch." CAB investigators are said to have suggested freak icing as the probable reason for the engines being stopped.

MOSCOW RECORD.—Russia has submitted to the F.A.I., for homologation, details of a flight by an Ilyushin Il-18 which carried more than 19 tons to 39,957 ft.

QUICK REPAIR.—The de Havilland Comet 4 G-APDL, which made a wheels-up landing at Rome on December 23, was flown back to London Airport on February 6 and has now returned to line service. Complete repairs, and a check two, were made at Rome by B.O.A.C. engineers and a D.H. working party. Damage was comparatively slight, the most difficult part of the repairs being the replacement of ribs, etc., in the centre section. All underside doors, the inboard flaps and one pod tank were renewed, and new engines were installed.

MORE SAFETY RULES.—New rules proposed by the F.A.A. will apply to all jet aircraft (U.S. and foreign) flying above 24,000 ft. over the U.S.A. The proposal is to set up 32-mile-wide radar-monitored airways at altitudes from 24,000 ft. to 39,000 ft.; require all jets to fly on these routes and to have radar transponders; and to allow piston and turboprop types on these routes if fitted with transponders or otherwise only when given A.T.C. clearance.

A.T.C. DISCUSSED.—An Air Navigation meeting for the ICAO African-Indian Ocean Region began in Rome on January 26 and was expected to continue until February 20. The meeting, at which States located geographically or having territories within the region, or having international civil aviation interests within the region, are represented, is concerned with air navigation facilities and services with particular reference to jet transports.

GOING DOWN.—The latest Market Report of the Aircraft Exchange contains offers of one Constellation 049 and three Constellation 1049Gs at well below any previous offering prices—$150,000 for the 049, and $1,600,000 for the three 1049Gs with spares including eight extra engines.

EUROPEAN AGENT.—The Hong Kong Aircraft Engineering Co., Ltd., has appointed as its agents in Europe, Killick Martin and Co., Ltd., of Dunster House, 20 Mark Lane, London, E.C.3.

BOLIVIAN ACCIDENT.—A Douglas DC-4 of Lloyd Aereo Boliviano crashed on a flight to La Paz from Cochabamba on February 5. All 58 occupants were killed. It was the fifth major airline disaster involving passenger fatalities this year (see our issue for January 29, p. 131).

News About People

A MILES APPOINTMENT.—Mr. Walter Browning, F.R.Ae.S., M.I.Mech.E., M.I.Prod.E., has joined the board of Miles Electronics, Ltd., and becomes general manager. Since 1947 he had been director and general manager of Saunders-Roe.

GAPAN CHANGES.—Major J. L. B. H. Cordes, F.R.S.A., A.F.R.Ae.S., has retired from his post as Clerk to the Guild of Air Pilots and Air Navigators. Succeeding Major Cordes as Clerk to GAPAN is Mr. V. C. Varcoe, O.B.E., A.R.Ae.S., who joined the Guild in 1952.

SWISSAIR IN U.K.—Mr. Max. A. Landolt has been appointed Swissair's sales manager for the U.K. and Ireland, in succession to Mr. Keller, whose appointment as general manager has already been noted. He has been manager for Singapore, Malaya and Indonesia since 1958.

B.O.A.C.'s NEW D.S.M.s.—Following B.O.A.C.'s recent major reorganization of its sales department in the U.S., four new district sales managers have been appointed. They are Mr. Ian A. Wood, Philadelphia; Mr. Anthony S. Linney, Cleveland; Mr. Trevor R. Richards, Chicago, and Mr. Basil Randall, Miami.

GP. CAPT. W. W. DEANE.—We regret to record the death of Group Captain W. W. Deane, C.B.E., personal assistant to Mr. Eoin Mekie, chairman of Silver City Airways, Ltd. He was 63, and joined Silver City in 1954 as chief administrative officer at Lydd Airport.

P.A.A. APPOINTMENT.—Mr. Herbert F. Milley has been appointed traffic and sales manager for the new Overseas Division of Pan American Airways (see our issue, January 8, page 50). He has been with P.A.A. since 1946 and became traffic/sales manager for the old Pacific-Alaska Division in 1949.

T.K.S. DIRECTOR.—Mr. Dennis Cameron Tanner, technical representative of T.K.S. (Aircraft De-icing), Ltd., has been appointed to the company's board.

HAWKER SIDDELEY SALES.—Mr. R. J. Falk has joined Hawker Siddeley Aviation from Avro to become sales executive for Central and South America. He will be responsible for sales of civil aircraft—particularly the Argosy and the Avro 748—and will be based in Mexico.

COCKPIT MOCK-UP.—Mr. Godrey Auty, deputy chief test pilot of Bristol Aircraft, in the full-scale cockpit mock-up of the Bristol 188. He will pilot the aircraft on its first flight later this year.

Air Transport

Stretching the VC10

CONFIRMATION is expected shortly of the recent unofficial reports that B.O.A.C. is to order 10 improved models of the Vickers VC10. The variant in question, known as the Super VC10, has been designed to extract the maximum value from the existing VC10 wing and powerplant for the North Atlantic route. As the airfields at each end of this route have already been extended for the first-generation turbojets now in service, it is feasible to allow the weight of the VC10 to increase by 45,000 lb. or so for North Atlantic operation, without increased power to maintain existing take-off distances.

This extra weight is being used to increase the passenger accommodation, to about 200, in a fuselage some 30 ft. longer than that of the original VC10. No increase in fuel is planned for this version, and because of the higher weights the absolute range is likely to be a little less, although still adequate for the North Atlantic. To increase the range of the VC10 (there has already been some airline interest in ultra-long-range transports which might be able to fly, for instance, non-stop from London to San Francisco or Johannesburg) a new wing would probably be required, and this possibility is being studied by Vickers as an exercise quite separate from the Super VC10.

With its order for Super VC10s, B.O.A.C. will, in effect, be taking up half of its option on 20 of these aircraft, which was taken when the order for 35 VC10s was placed in January, 1958. The extra 10 aircraft will follow on after this batch of 35, with deliveries starting in 1965. The first VC10 (a Vickers prototype) is scheduled to fly in June, 1961, and deliveries to B.O.A.C. to begin in June, 1963, and end in July, 1965. In its basic form the VC10 weighs 299,000 lb., is powered by four 20,250-lb.s.t. Rolls-Royce Conway R.Co.42s, and carries up to 150 passengers in a fuselage 158 ft. 10 in. long.

The Super VC10 is the largest and heaviest turbojet transport so far announced. Boeing has a comparable project in its 707-520, which would have a redesigned wing and more powerful engines—either Conway R.Co.42s or Pratt & Whitney JTF-9 turbofans of similar power.

The Cost of the 707 Delay

B.O.A.C. will suffer a heavy financial penalty for the delay in delivery of its fleet of Boeing 707s (see our previous issue). The original contract specified delivery of the first aeroplane by the last day of 1959, with the second in February, one a month from March to September and two each in October, November and December. This would have made it possible to start service on the North Atlantic in mid-April and to build up frequencies in line with the peak summer traffic.

Delivery of the first aeroplane is now unlikely before the end of March, and the incorporation of modifications in the others will delay those also. This means that for much of the 1960 summer season B.O.A.C. will be able to offer, at best, only a few 707 services each week, at a time when 12 of the 16 airlines flying regularly on the North Atlantic routes will be operating non-stop jet services. It was, in any case, the Corporation's intention to support its 707 services with Comets, Britannias and DC-7Cs until the end of the season; but it is now clear that these types will have to provide the bulk of the capacity. In these circumstances, B.O.A.C. can hardly hope to retain its share (around 40% at present) of the traffic between the U.K. and the U.S.A., let alone increase it to the "target" value of 50%.

The loss of revenue and the higher training costs resulting from the delayed 707 programme may not be the only burden on B.O.A.C.'s finances. The cost of the modifications may also be charged to the Corporation. The position seems to be that Boeing had developed these modifications (rudder boost, "slave" yaw damper, taller fin and ventral fin) to improve the handling of the Intercontinental 707-320 and -420, and is offering them to all airlines with these types on order. Both the -320 and -420 have, however, been approved by the F.A.A. without these modifications, and the A.R.B. is the only airworthiness authority so far to have refused to validate the American certificate without having demonstrated the effects of the modifications.

Therefore, B.O.A.C. must have the modifications in order to get approval to operate the 707, but Boeing can, it seems, argue that the modifications are optional and should be paid for by the customer. Most airworthiness authorities have, apparently, been content to validate the F.A.A. certificate for the 707 Intercontinental, without conducting the additional tests which the A.R.B., with its unequalled experience of jet transports, considered were necessary.

P.I.A. Leases a Turbojet

THE problem faced by some of the smaller national airlines in competing successfully against the better-equipped long-haul giants has been solved by Pakistan International Airlines through the lease of a Boeing 707-320 from Pan American.

From the first week in March until October this year P.I.A. will lease this aircraft on a trip basis for a once-weekly return Karachi-Rome-London service and it will operate in Pan American colours. From October a 707 will be fully leased and will operate up to three times weekly on the European, and possibly on other, routes in P.I.A. colours. During the initial period Pan American flight-deck crews will handle the aircraft with Pakistani cabin crews, but from October it is expected that the aircraft will be manned entirely by Pakistani crews; pilots and flight engineers have already started conversion training at Seattle.

The arrangement will not only allow P.I.A. to compete satisfactorily with other operators on the Pakistan-Europe route, but will provide the means of turbojet operating and engineering experience in preparation for possible turbojet purchases at a later date. It will, in fact be open to P.I.A. to buy the leased 707 at an adjusted price. Meanwhile, the terms of the lease are such that P.I.A. will be able to break even with 47 passengers (39%) plus normal freight and mail.

Apparently the prospective passenger and freight traffic on the domestic services between the two wings of the country is such that P.I.A.'s L-1049s are likely to be fully occupied.

FIRST S.A.S.—The long-range intercontinental version of the DC-8, with JT-4A engines and a max. take-off weight of 310,000 lb., was certificated by the F.A.A. on February 4. The first intercontinental DC-8 for S.A.S. is illustrated; other operators with this JT-4A-engined model on order are J.A.L., K.L.M., Northwest, Olympic, P.A.A., Panair do Brasil, Panagra, Philippine Air Lines, Swissair, T.A.I. and U.A.T.

Air Transport . . . .

The Air-freight Business

THOSE who have been in air transport for a long time will by now have learned to be cynical of optimistic clichés which are periodically applied to the air-freight business—usually to the effect that it is the "sleeping giant of commercial aviation." All that can be said is that the giant now shows real signs of waking, after periodic yawns during the better part of a decade. As we pointed out in this column on January 8, the ton-mile increase-rate has varied irregularly between 2% and 36% during the past 10 years and the lowest rate of increase was that of 1957-58, when the giant chose the North American recessional period as an excuse for another inter-yawn nap.

A Douglas Aircraft vice-president, Mr. J. R. McGowen, again referred last month to this "sleeping giant" and said that "technically the airplane is ready. Turbofan and turboprop cargo airplanes can be delivered within two to three years which can cut operating costs in half." After explaining that fully mechanized cargo-handling systems will be developed, with automatic sorting, routeing and billing, he said that domestic rates would drop first to about 14 cents and then to 10 cents a ton-mile. But, he also said, a shortage of capital on the part of the airlines, which have invested heavily in passenger transports, might be cited as the principal factor holding back air-cargo development.

And there we rest once again. It seems that the airlines may need, for several years yet, to manage with cargo conversions of outmoded piston-engined aircraft—which cannot be sold and the cost of which has not been written off—and with the cargo fill-up volumes which the new turbojets have to offer. The manufacturers cannot build new all-cargo aircraft unless sufficiently large orders come in, from the airlines or from the Air Force, to cover development costs, and most of the airlines have difficulty enough in paying for the present-generation turbojet transports—and, later, for the medium-jets which competition will force them to order in the near future.

Can there ever be, in fact, anything really like the freight "break-through" which is so readily talked about? The business is an immensely complicated one and a rapid increase in freight traffic will only be possible if everything turns in its favour at the same time. For instance, the specialized freight aircraft will be a commercial proposition only if it can be operated, like other aircraft, at a high utilization. This, in its turn, means the prior education of shippers and consignees to accept the need for round-the-clock preparation and acceptance of shipments. In their turn, the airlines will need to remove much of the complication of the present basic and commodity rate systems, taking the rough with the smooth for an overall profit. Predictions—such as that of a future U.S. domestic rate of 10 cents per ton-mile—mean very little when considered in relation to the situation in North America, where individual freight rates are probably more varied than anywhere else in the World.

Apropos mechanized loading systems, American Airlines' vice-president of equipment and research, Mr. William Littlewood, said recently that any turbojet all-cargo transport ordered by his company will need to be equipped with such a system as an integral part of the aircraft. If, he said, we are to increase the capacity three-fold without a mechanized loading system, we would simply be increasing the required ground time three-fold and thus be dissipating the speed advantage of the turbine-powered aircraft.

To help to sell the increased capacity being made available by its 707 fleet, B.O.A.C. is organizing a major expansion of its cargo sales department in the U.S.A. Five new cargo sales representatives have been appointed for Boston, Washington, Detroit, Chicago and Dallas, and new assistants for the existing offices at New York, San Francisco and Los Angeles.

Italian Helicopter Operators

ELIPADANA, the helicopter-operating company set up by the city of Milan, has ceased operations for the winter, writes an Italian correspondent. The company has been operating an experimental Milan-Malpensa-Lugano service with a chartered Vertol 44B for two months, primarily to obtain operating experience and cost data (see "Helicopter Markets in Italy," November 6, 1959, issue).

As a result of the interest aroused by Elipadana's plans and public experiments, the cities of Turin, Venice, Trieste, Verona and Bergamo have asked to be permitted to participate financially in the company. This has been agreed and the initial capital of the company will accordingly be increased by some 50%. Other shareholders are the Commune of Milan, an association of Italian industries, and the Cassa di Risparmio. It is also strongly rumoured that Fiat will become shareholders.

When Elipadana continues its experimental services later this year, it will again concentrate on obtaining factual cost data over the various routes which it proposes to operate eventually. The eight-nine-passenger Agusta 102 may be evaluated on these routes, and the Vertol 44 or other types will probably be chartered again. A Westland offer to make available one of the prototype Westminsters, with a covered framework and some passenger accommodation, has been withdrawn, to Elipadana's great regret, as this aircraft is now wanted for Westland's accelerated development programme on the civil Westminster 1.

Meanwhile, as recently reported, another Italian helicopter operator, Linée Aerée Sardé, has indicated its intention of ordering three of the developed Westminsters, which it hopes will be delivered in 1962.

Elivie, the helicopter-operating company associated with Alitalia, has decided to order three Agusta 102s, with accommodation for eight passengers. A developed version of this design, the Agusta 204, with turbine engine, is to fly this year.

Transport Helicopter Break-through?

NEW YORK AIRWAYS—with probably more knowledge of the helicopter transportation business than any other operator in the World—believes that it can be operating profitably without subsidy by 1965-66 with a fleet of 10 Vertol 107s. This note of well-founded optimism was struck by N.Y.A.'s president, Mr. Robert L. Cummings, in a paper last week.*

After describing the type of operation—"Direct Service" from point of origin to destination with the minimum of dependence on ground transport—in which N.Y.A. has specialized since it carried its first passenger on July 8, 1953, Mr. Cummings traced the company's growth, and its decreasing dependence on subsidy. In 1954, the number of seat-miles produced was 725,000 and the subsidy need per available seat-mile was $3.61; in 1959 these figures were 15 million and 32 cents respectively. The percentage of revenues derived from commercial sources has risen from 7% to 35% in five years.

N.Y.A. has operated five types of helicopter to date, and has now decided, after "many hundreds of man-hours of intensive study and evaluation," to replace its present fleet of five 15-passenger Vertol 44Bs with 25-passenger Vertol 107s. In 1961, five of these twin-turbine (General Electric T58) helicopters will be introduced; with their larger capacity and guaranteed cruising speed of 135 knots they will immediately multiply by almost four the available seat-miles, from 5,800,000 to 22,000,000.

The subsidy requirement per available seat-mile will decrease from 48 cents with the Vertol 44 to 12 cents with the initial fleet of five Vertol 107s. As required, the fleet will be built up to 10, which will produce about 55 million seat-miles per year, and will reduce the subsidy requirement to zero.

With so much extra capacity, N.Y.A. will take vigorous steps to increase its traffic. The number of passengers is expected to grow from 125,000 in 1959 to a million in 1964. Many existing routes will be operated at very high frequency in an attempt to make advance reservations unnecessary and do away with much paperwork. Services to suburban communities and neighbouring cities will be expanded.

A new type of high-frequency service is being investigated to carry commuters during peak hours between heliports in the centre of New York and landing sites at large car parks on the outskirts of the metropolitan district. Growing congestion on the roads is expected to make this service popular.

Attention will also be given to reducing transit times. Assuming that each of five Vertol 107s is away from the hangar for 6½ hr. a day throughout the year, Mr. Cummings showed that a saving of one minute on the average transit time per stop (four minutes at present) would increase available seat-miles by over two million a year, and the annual revenue by $442,000.

Mr. Cummings concluded his paper with the following reference to N.Y.A.'s long-term plans ". . . it is reasonable to assume that sooner or later elementary economics will result in New York Airways Direct Service mission being accomplished by aircraft other than conventional rotary wing and therefore capable of higher speeds as well as vertical flight. Last year, with this thought in mind, we entered into an agreement with the Fairey Aviation Company, which covers New York Airways' right to purchase a fleet of Rotodyne airliners. We look forward to putting these aircraft into service some time in 1965."

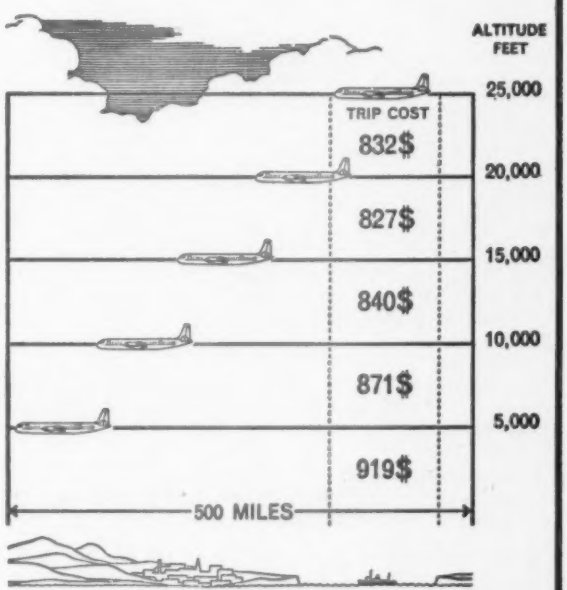
* "Vertical Transport Business," by Robert L. Cummings, Jr., presented at the inaugural meeting of the Royal Aeronautical Society Rotorcraft Section on February 5.

Only the VANGUARD
has this proved flexibility

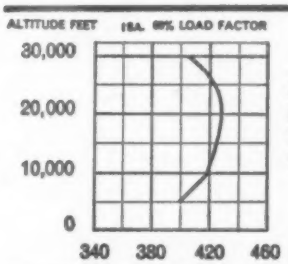
AIRLINE OPERATORS are invited to look carefully at this diagram and graph, and then compare the Vanguard's flexibility with their own experience of short haul operation on high-density routes.

It is easy to see that this remarkable aircraft can be routed at altitudes of from 5,000 ft to 25,000 ft and above, with practically no penalties in operating costs or speed.

The difference in direct cost between a 500-mile sector flown at 10,000 ft and one flown at an optimum of 20,000 ft is only $44 per trip. A cruising speed of over 400 m.p.h. is available between the height bands of 5,000 ft and 30,000 ft., so that schedules can be maintained irrespective of routeing instructions.



LOW LEVEL ROUTEING IMPOSES NO FINANCIAL STRAIN WITH THE VANGUARD



SPEED CAN BE MAINTAINED WHATEVER THE ALTITUDE ROUTEING INSTRUCTIONS

Of all the airliners only the Vanguard has all these features

425 m.p.h. cruising • Freight capacity 7/8 tons at normal densities • Full routeing and A.T.C. flexibility • Can use normal existing airfields • Quick turn-round • No airfield noise problems • Ten years' unique Vickers/Rolls-Royce turbo-prop experience . . . ***And it is 'Viscount' quiet.***

VICKERS VANGUARD

FOUR ROLLS-ROYCE TYNE TURBO-PROP ENGINES

• ***The airliner with the biggest profit potential ever offered to the operator***

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY

AT 634

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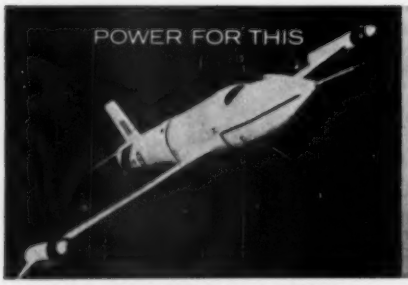
...AND BRISTOL SIDDELEY SUPPLY THE POWER

One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Viper. A turbojet in the 1,700 to 3,000-lb thrust class, the Viper has proved itself in service to have those qualities which are particularly desirable in powerplants for trainer aircraft: great robustness and reliability, indifference to mishandling and a long overhaul life.

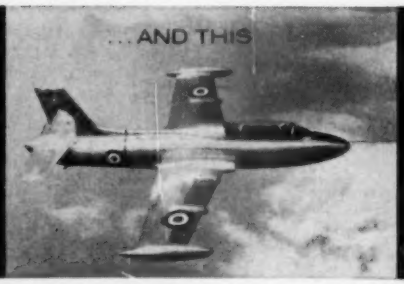
Illustrated above is the Hunting Jet Provost, the first jet to be standardised by any air force for primary training. The Bristol Siddeley Viper ASV 8 (1,750-lb thrust) gives the Provost a very lively all-round performance. When the Jet Provost Mk 1 began service trials with the RAF, over 1,500 hours were completed by nine aircraft in the first six months without a single premature engine removal!

That the Jet Provost is also a versatile aeroplane with plenty of "stretch" is well demonstrated by two later developments:—an armed version, in service with the Royal Ceylon Air Force and an advanced version powered by the Viper 11. The latter, which is under intensive development, has a greatly increased performance—a climb of 4,000 ft/min and a ceiling of 40,000 ft!

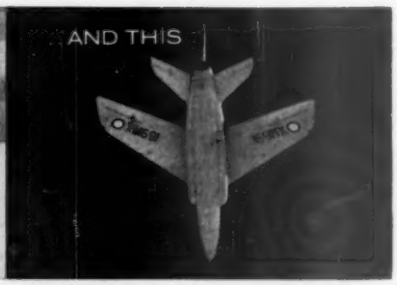
BRISTOL SIDDELEY ENGINES LIMITED



The Bristol Siddeley Viper 11 powers the Australian Jindivik Mk 3 target drone.



The Bristol Siddeley Viper 11 powers the Macchi MB 326 jet trainer.



The Bristol Siddeley Orpheus 100 powers the Folland Gnat trainer.

Air Transport . . . .

The Largest Airport Ever

EXPECTED to be open to traffic by the middle of 1961, Dulles (Washington) International Airport is believed to be the largest airport project ever undertaken. Covering 9,600 acres, it is twice as large as New York's Idlewild, and has been planned so that no additional land acquisition will be necessary as far ahead as can be foreseen.

F.A.A. estimates indicate that 4 million passengers will be using Dulles International by 1965, increasing to 6.6 million in 1970 and nearly 9 million by 1975. The present Washington National Airport, which handled 4.5 million passengers in 1958, will be close to saturation point at 6 million passengers a year It will continue to be used in addition to Dulles, and its location close to the city centre will retain its popularity with travellers although it is not suitable for jet services. The precise division of traffic between Washington National and International Airports has not been decided.

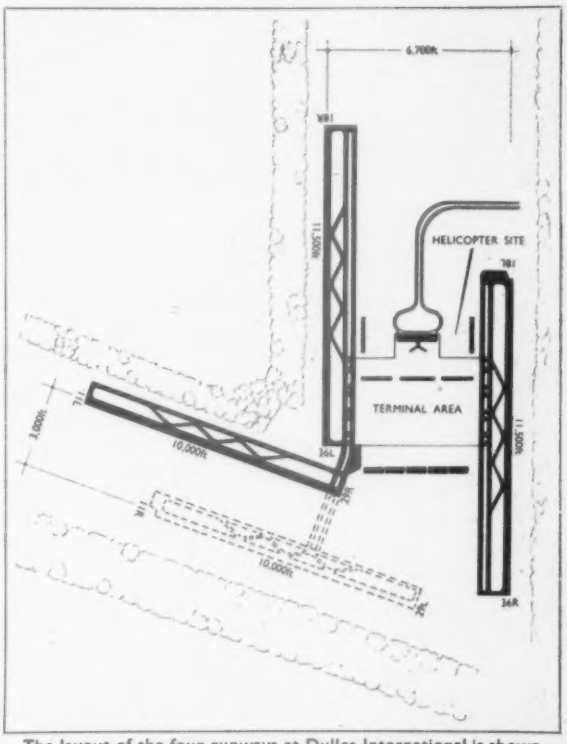
Work at the Chantilly site—23 miles west of the White House—has been proceeding rapidly since the final choice was made in January, 1958 (land had previously been acquired at Burke, Virginia, as early as 1951, but this site was abandoned after prolonged controversy). Bad weather has, however, recently interrupted work on the runways, so that the target of January, 1961, for the first flying operations at Dulles, has had to be put back by a few months.

The runway layout adopted at Dulles comprises two parallel pairs, each runway overlapping for approximately 50% of its length with its parallel partner. The two main runways lie north-south and are 11,500 ft. long with 6,700-ft. separation. The other pair are almost at right angles, lying W.N.W./E.S.E., and these are 10,000 ft. long with 3,000-ft. separation. Work on the first N./S. runway began on June 29, 1959, and was finished on August 28, and the second N./S. runway was laid between September 28 and October 22, 1959. As the photograph here shows, work on the first W.N.W./E.S.E. runway was well advanced before operations closed down for the winter; the second W.N.W./E.S.E. runway is for construction later.

Each runway is 150 ft. wide with 25-ft. shoulders, and is designed for a 100,000-lb. single-wheel load, based on a 200-p.s.i. footprint pressure, which will be adequate for aircraft up to 500,000-lb. gross weight. The runways will have high-speed turn-offs (designed for 60-m.p.h. exit speeds). Provision is being made for narrow-gauge lighting, extending 3,000 ft. down the runway from each threshold, with the two bars of lights separated by 60 ft. This type of lighting is required on instrument runways and initially will be installed only at each end of the 18L/36R runway, which will normally be reserved for landings. In case more ILS equipment is installed on other runways later, appropriate bases for narrow-gauge lighting have been provided on all runways during their construction.

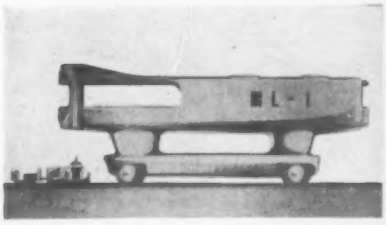
Much thought has been given to arrangements in the terminal area to reduce the distance walked by passengers between the check-in desk and the aircraft. The system adopted at Dulles is known as the mobile-lounge concept and is a logical extension of that used at London Airport and elsewhere, where coaches are used to convey passengers between the "airside" departure and arrival lounges and the aircraft.

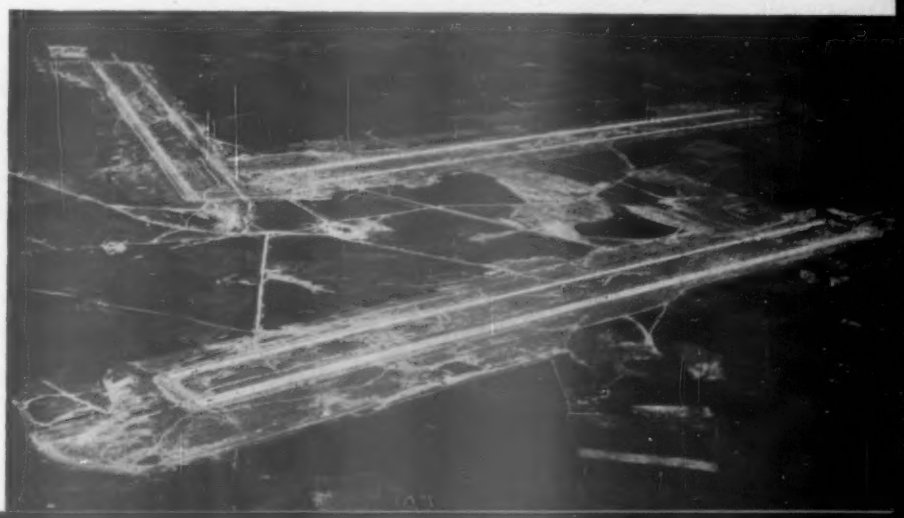
The mobile lounge is, in effect, a coach designed specifically and solely for the job of shuttling passengers to and fro across the apron, and with facilities for loading and unloading directly at aircraft-cabin level. A prototype 80-seat mobile lounge is being built by the Chrysler Corporation and will be ready for tests in April; about 20 are to be purchased initially for use at Dulles and will be leased from the airport authorities by the airlines.



The layout of the four runways at Dulles International is shown in this diagram (reproduced from a recently published report on Parallel Runway Systems by the A.D.V., Stuttgart).

The terminal area will be located within the overlapping area of the two long runways and will be served by an 18-mile high-speed access road linking with a new circumferential highway around Washington. The terminal building itself will be about 600 ft. by 150 ft. and will be on two floors, of which the upper, main floor will be primarily for departures. Arriving passengers will pick up their baggage on the ground floor and proceed straight to coaches for the town centre. An access road will be provided for the upper floor as well as one at ground level.





Right, the progress of work on the first three runways at Dulles is shown in this recent picture. Above, an impression of the Chrysler mobile lounge which will be used in the terminal area to ferry passengers between aircraft and terminal building.

The Fighting Services

Air Rank Appointments

AIR COMMODORE A. R. D. MACDONELL, D.F.C., Officer Commanding, R.A.F. South Cerney, is to become Director of Work Study at the Air Ministry. Appointed Director of Studies at the Joint Services School for Linguists in 1951, he was Air Attaché in Moscow from 1956 to 1958 before going to South Cerney.

Gp. Capt. J. A. Robinson, O.B.E., Senior Technical Staff Officer at Headquarters, Signals Command, has been appointed Chief Signals Officer at Bomber Command, with the acting rank of Air Cdre. In 1950 he went to Flying Training Command as Chief Signals Officer, and in 1953 was posted to Headquarters, F.E.A.F., in the same appointment. He has been with Signals Command since 1957.

Efficiency Rewarded

THE Fleet Air Arm's premier award for the finest feat of aviation in the Royal Navy, the Boyd Trophy, has been awarded to No. 781 Communications Squadron for the way in which it met exacting tasks during 1959. The Squadron is based at R.N.A.S. Lee-on-Solent and is the Service's smallest squadron with six Sea Devons and one Whirlwind.

During last year No. 781 Squadron flew a total of 4,200 hr. by day and 50 hr. by night, carrying 2,720 passengers and 100,000 lb. of freight without accident.

"Their Name Liveth"

A NEW book in the Imperial War Graves Commission series "Their Name Liveth" has now been published. It contains photographs and descriptions of war cemeteries and memorials built by the Commission in its task of commemorating those of the Commonwealth Forces who died during the two World Wars.

This book, Volume IV, in Part 2 of this series, covers burial grounds in the United Kingdom where there are graves of Commonwealth airmen who died during the late War. The introduction has been written by Air Chief Marshal Sir Philip Joubert and part of the book is devoted to the Commonwealth Air Forces Memorial at Runnymede. Copies may be obtained from the Imperial War Graves Commission, Wooburn House, Wooburn Green, High Wycombe, Bucks, price 5s. 7d. inclusive of postage.

Australian Defence Changes

FURTHER information on the proposed changes in the R.A.A.F. (see THE AEROPLANE AND ASTRONAUTICS, December 18, 1959) has been given by Air Marshal Sir Frederick Scherger, Chief of the Australian Air Staff. The first major development is in the rôle of the so-called Australian home defence forces.

Because the technical complexity of the latest aircraft and weapons systems require full-time and specialist training, it has been decided that in future Australian Citizens' Air Force squadrons would be trained in the non-flying rôle only. This would allow them to be better trained and more readily available for operational duties in any emergency. C.A.F. squadrons at Adelaide and Sydney have already ceased flying training, and by the middle of this year the remaining squadrons at Perth, Melbourne and Brisbane would be absorbed into ground duties.

Other developments include the formation of a new fighter squadron—No. 76 Sqn.—to be equipped with Commonwealth CA-27 Sabres. To be based at R.A.A.F. Williamtown, it will use Vampire Mk. 35s initially but should receive Sabres within a year. No. 10 (MR) Squadron at R.A.A.F. Townsville is to have its G.A.F. Lincolns replaced by Lockheed P2V-5 Neptunes; the last of No. 11 Squadron's Neptunes have now returned from the United States, where they have been fitted with Westinghouse J.34 turbojets.

In addition, eight helicopters will be bought, and will probably be formed into No. 9 Squadron.

Sidewinder AAMs for the two R.A.A.F. Sabre squadrons in Malaya are being flown direct to R.A.A.F. Butterworth from the United States. Expected to be equipped with missiles this month, the fighters have already been modified by the addition of two underwing pylons designed and manufactured by the Commonwealth Aircraft Corporation in conjunction with the Aircraft Research and Development Unit at Laverton. The missiles are being flown out to Malaya by R.A.A.F. Hercules transports.

R.A.F. Appointments

THE following are among recent Royal Air Force appointments:—

Air Ministry: Sqn. Ldr. R. Whittam to the Department of the Chief of the Air Staff, with acting rank of Wg. Cdr.

Bomber Command: Sqn. Ldr. W. N. Gilmer, A.F.C., to R.A.F. Wittering to command the Bomber Command Development Unit, with acting rank of Wg. Cdr.

Fighter Command: Sqn. Ldr. A. D. Woodcock, A.F.C., to R.A.F. Wattisham to command the Flying Wing, with acting rank of Wg. Cdr.

Flying Training Command: Gp. Capt. T. C. Musgrave, O.B.E., D.F.C., to R.A.F. South Cerney to command.

Technical Training Command: Gp. Capt. M. Wyatt, D.F.C., to R.A.F. Bircham Newton to command.

British Forces Arabian Peninsula: Wg. Cdr. B. G. Meharg, A.F.C., to Headquarters as Senior Personnel Staff Officer; Wg. Cdr. A. B. J. Pearson, A.F.C., to R.A.F. Khormaksar as Wing Commander, Transport Operations.

Other Appointments: Gp. Capt. J. E. Johnson, C.B.E., D.S.O., D.F.C., Gp. Capt. E. G. L. Millington, C.B.E., D.F.C., and Gp. Capt. J. R. Whelan, D.S.O., D.F.C., to the 1960 Imperial Defence College Course; Wg. Cdr. D. G. H. Spencer, M.B.E., to Pakistan as Air Adviser to the High Commissioner, with acting rank of Gp. Capt.; Wg. Cdr. M. A. Ensor, D.S.O., D.F.C., A.F.C., to the Armed Forces Staff College, Norfolk, Virginia, for studies; Wg. Cdr. H. R. Kerr, M.B.E., to the Operations Staff, Air Pacific Fleet.

STRATEGIC RECONNAISSANCE.—During repairs to the main runway at R.A.F. Wyton, V-bombers from the strategic reconnaissance base operated from the nearby U.S.A.F. base of Alconbury. At a recent luncheon a model of a Victor was presented by Gp. Capt. C. D. North-Lewis, D.S.O., D.F.C. (above, centre), to Col. V. N. Cabas, Deputy Commander of the 10th Tactical Recce Wing (left), while Col. H. S. Taylor, Commander of the 10th U.S.A.F. Air Base Group looked on. Left, the three types operating from R.A.F. Wyton—Victor B.1, Valiant B(PR)K.1 and Canberra PR.7.

the Whirlwind* means Mobility

* The piston-engined Whirlwind is in operation with Armed Services throughout the world. An experimental turbine-powered version points to even better performance, extended usefulness and simplified maintenance in later types of this ubiquitous helicopter.

WESTLAND a great name in Helicopters

WESTLAND AIRCRAFT LIMITED YEOVIL SOMERSET ENGLAND

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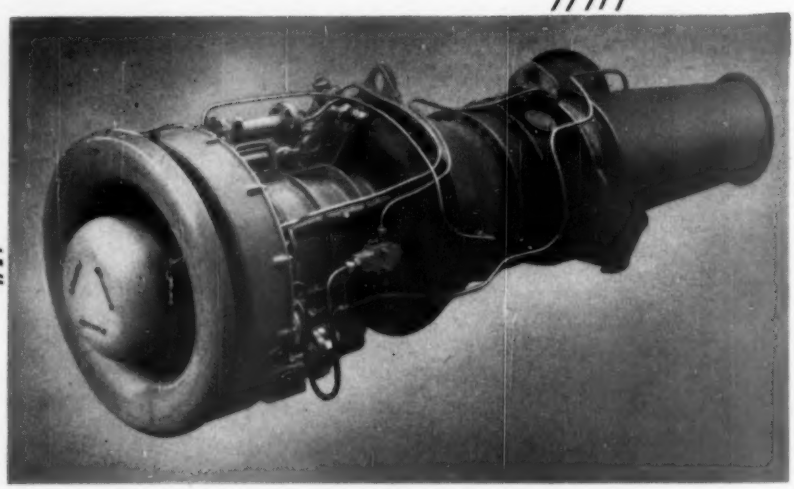
(LICENSEES FOR TURBOMECA ENGINES)

NIMBUS (A.129)

a free-turbine engine giving over 1000 h.p.—

developed as a result of unique experience in the field of small gas turbine design and production



The Blackburn Nimbus initially is applied to helicopters and has been chosen to power the Saunders-Roe Wasp, but, like all the other small gas turbines in the Blackburn range,

The Palas
The Palouste
The Turmo
The Artouste

has a wide range of power applications.

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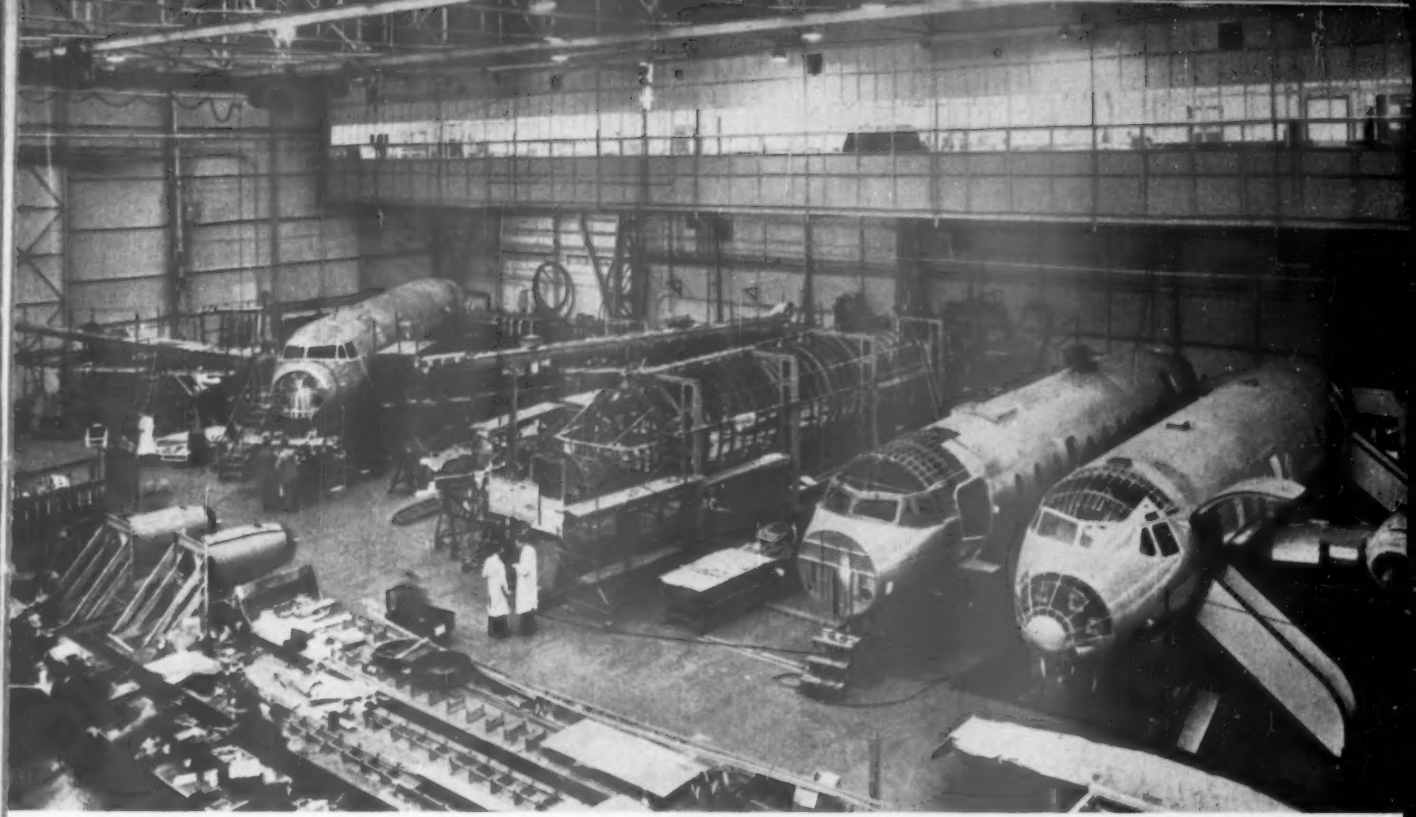


Structural Features of the Avro 748

IN their approach to the problem of providing an aeroplane for the "Dakota-replacement" market, the Avro design team has, right from the start, kept in mind the need to produce a utilitarian aircraft that was uncomplicated, inexpensive and reliable. The first prototype is nearing completion at Chadderton and should fly within the next two or three months. Two others are on the assembly line—one of them for static structural test—and a fourth is being built for fatigue testing in the Avro water tank later in the year.

A straightforward, comparatively orthodox low-wing monoplane, the Avro 748 is powered by two Rolls-Royce Dart turboprops and is capable of accommodating up to 47 passengers in a high-density layout of its pressurized cabin. It has behind it a great deal of careful thought and planning and its design background and overall concept were discussed at length in THE AEROPLANE AND ASTRONAUTICS for September 11, 1959. At this stage it is interesting to make a closer study of some of its detail structural features.

For the larger and more complicated airframes, because of their necessarily high stress levels and the likelihood of fatigue failures of one sort or another, the structural philosophy of "fail-safe" has come to be accepted as a technique that is widely applied. For the smaller, and consequently simpler, aircraft the fatigue danger may not be so high but this philosophy is no less desirable for it gives an added assurance of structural integrity which is of tremendous value to the operator who proposes to employ the aircraft concerned in underdeveloped areas from secondary airfields and without vast repair and maintenance installations.

In this respect, one of the principal features of the Avro 748 is the very careful thought that has gone into its detail structural design. This has been based on the general principle of fail-safe and the three complementary factors of accessibility for inspection, maintenance and repair; simplicity of structure; and continuity of structure. In this article we propose to set out the background thinking of the Avro team in these matters and to show how these factors have been applied in the 748's airframe.

First of the three principal applications of the fail-safe philosophy is the use of a stand-by. In this, the object is to provide a second load path, which normally stands completely idle, in case the basic member should fail. This approach, of course, represents a direct weight penalty and only "earns its keep" in the event of a failure.

For this reason, it is sparingly used and the only place in the 748 airframe where there is an example of the stand-by, is in the tailplane and fin attachments. Here, integral with the attachment forgings—and, therefore, giving only a small weight penalty—there is an ingenious key and slot fitting which, in the event of the attachment bolt failing, will carry the full load. The clearances in the key and slot are such that in normal circumstances no load is taken through them.

A development of the idle stand-by technique is what might, perhaps, be termed the working stand-by. In this the secondary load-path member has a task of its own to perform but is also capable of carrying additional load in the case of failure. In this case there is no direct weight penalty for the fail-safe feature.

In the 748 structure, a particularly good example of the working stand-by is to be found in the wing. For the aileron hinge brackets, aft of the rear spar, all that is really required in order to carry the hinge are simple members from the top and bottom flanges of the spar coming together at the hinge to form a rigid triangulation. It is, however, also necessary in this region to preserve the wing contour back to the hinge line and aileron leading-edge.

For this latter task the Avro design team have chosen to support the shrouds on a second pair of upper and lower members outside the primary hinge-carrying ones and to join all four together by side plates at the extremity. If, then, there is any failure of the primary members, the secondary shroud-support members can take the additional load and the fail-safe principle is applied.

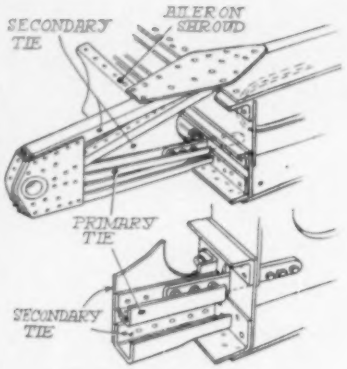
Another example of the working stand-by is in the flap-track mechanism. The steel tracks are supported each side by a wing rib so arranged that should the track develop a crack and become unable to take the bending loads unaided, the wing ribs will cope with the extra load.

The second means of obtaining a fail-safe characteristic is to have some form of simple duplication. Structurally, this is best applied in cases where loads are taken through comparatively slender members such as rib bracing or windscreen pillars. By building up such members with two components, a failure of either one need not result in complete collapse or dangerous structural weakness.

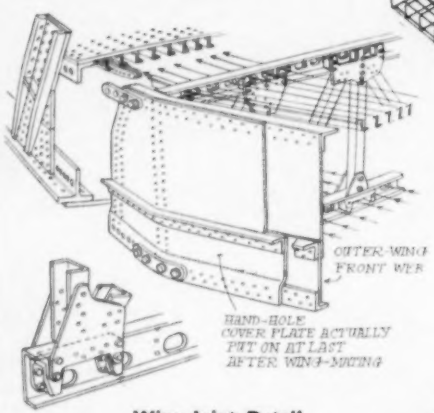
This approach will, of course, bring a fairly high weight

(*Continued on page 188*)

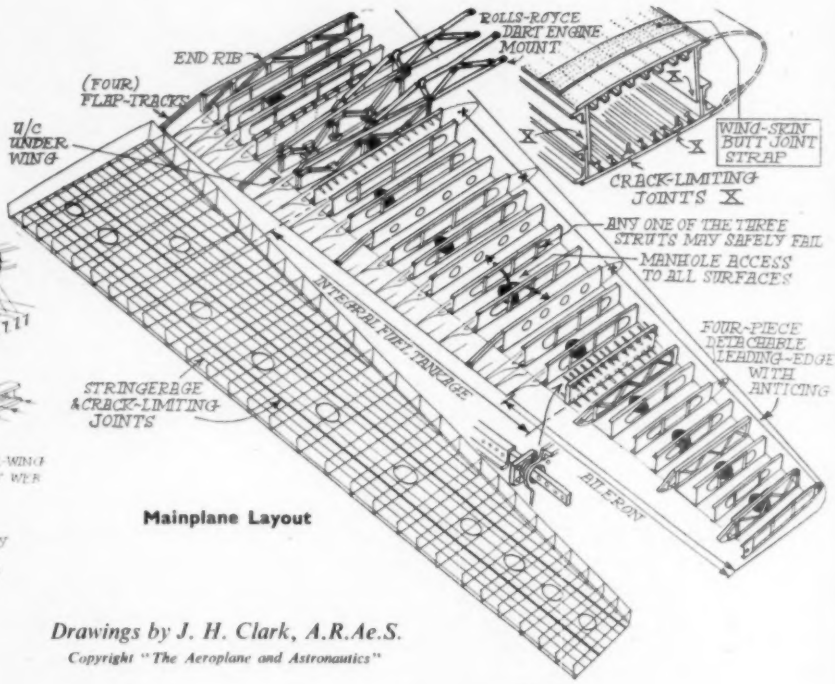
STRUCTURAL DETAILS OF THE AVRO 748



Aileron Hinge Bracket



Wing Joint Detail



Mainplane Layout

Drawings by J. H. Clark, A.R.Ae.S.

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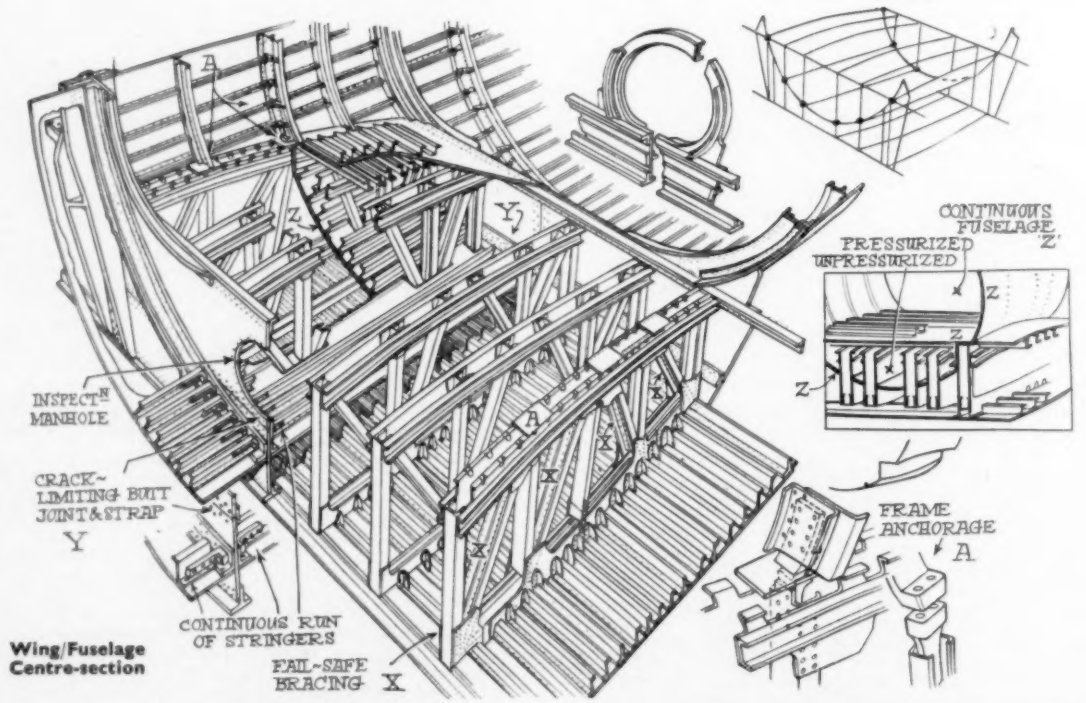
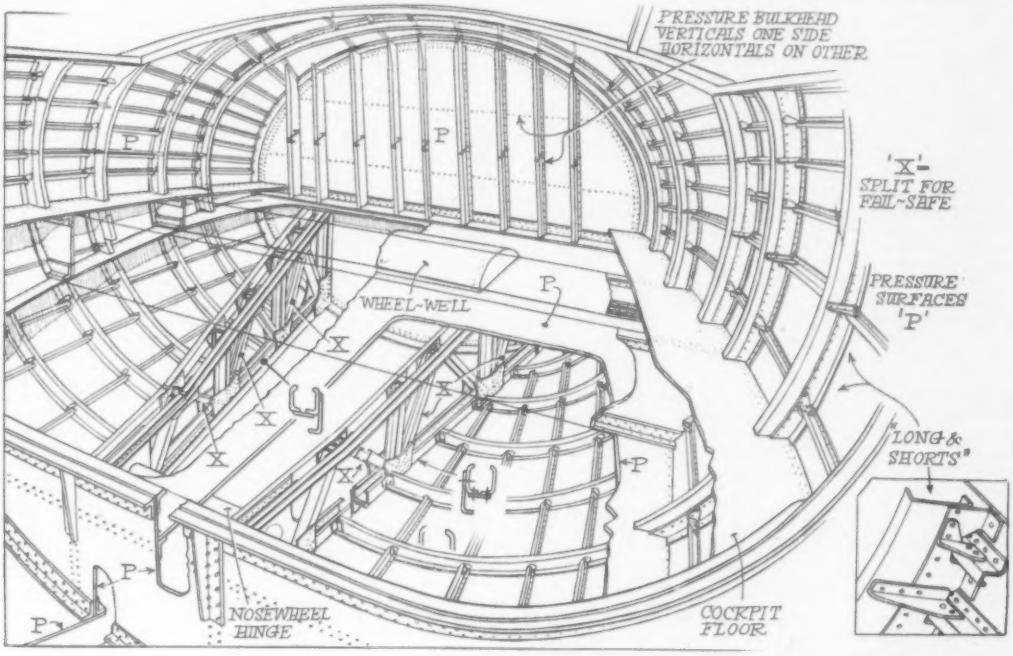
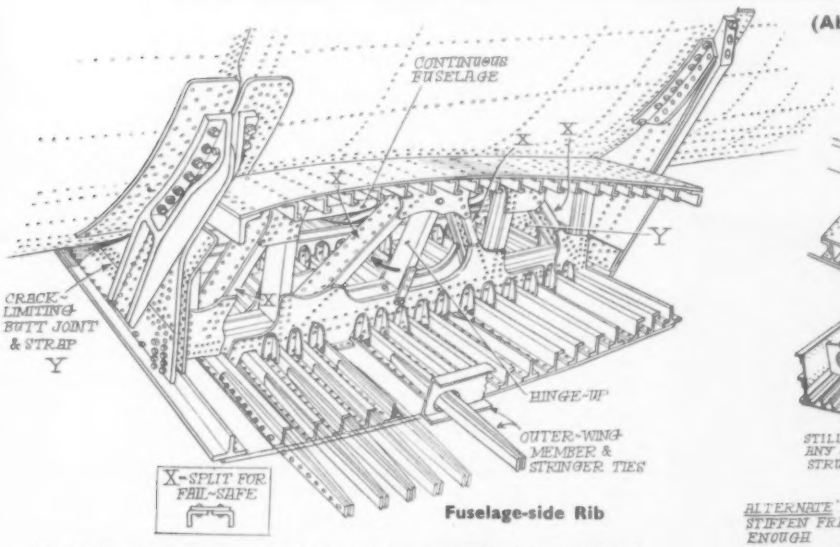


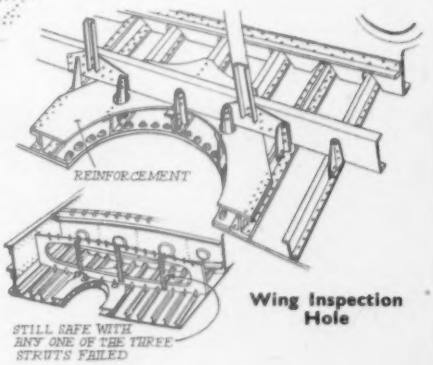
Wing/Fuselage Centre-section



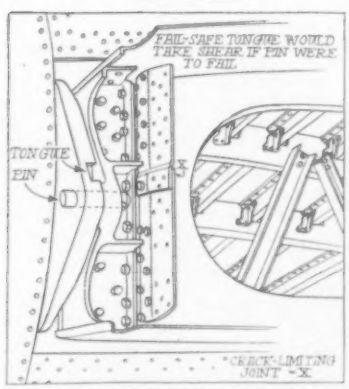
(Above) Fuselage Nose-wheel Bay



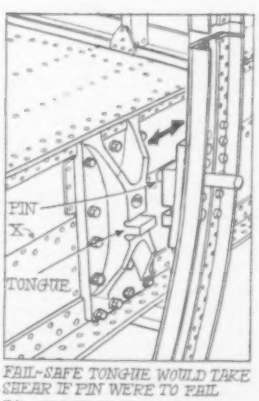
Fuselage-side Rib



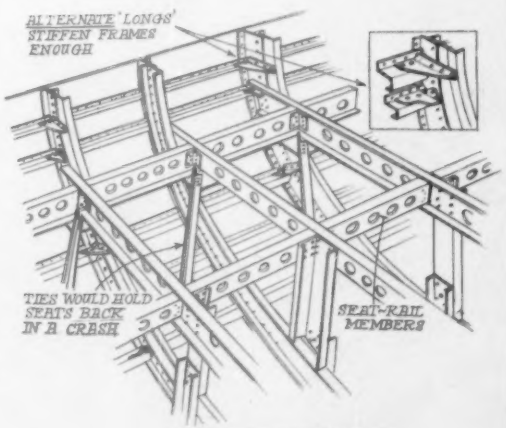
Wing Inspection Hole



Tailplane Attachment Fail-safe Standby Lugs



FAIL-SAFE TONGUE WOULD TAKE SHEAR IF PIN WERE TO FAIL
X- CRACK-LIMITING JOINT



Floor-support Structure

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(*Continued from page 185*)

penalty. But it should be borne in mind that to enjoy correspondingly low stress levels with a single member would also entail a fair amount of extra weight. Thus the mere fact of duplication is not quite so penalizing in the weight sense as it would appear at first sight.

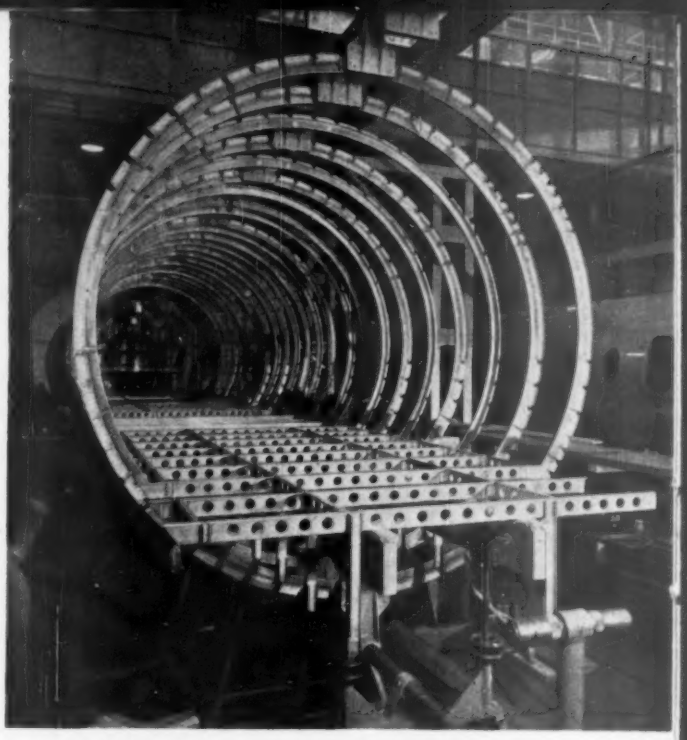
In practice, when duplication of this sort is employed, each "half" of the member is designed to carry 80% of the fully factored load. This means, for example, that where the factor is 1.5, in the case of failure of one half the remaining one can still carry 1.2 times the limit load. It follows that the duplicated member can carry 60% more than the factored load and has a correspondingly higher weight than that of a single member taking only the factored load.

A number of examples of this straightforward duplication are to be found in the 748. The sturdy built-up fuselage-side ribs in the centre-section, for instance, have doubled diagonal bracing members; and the top and bottom flanges of the other centre-section ribs, carrying the fuselage pressure loads from the top wing skin into the structure, are also built up from two components. In the case of the former, the required channel section is made up from two angles while for the latter the flanges comprise two channels, one each side of the vertical and diagonal bracing members.

In the case of the two main ribs carrying the undercarriage and engine mounting attachment fittings, the bracing members are inevitably bulky and here quadruplication rather than duplication has been selected. These members are of cruciform section and they are made up of four angles riveted together. This particular solution offers a much smaller (6% instead of 60%) weight penalty for the fail-safe feature; but has its drawbacks in increased complexity and a larger number of components.

A form of duplication, by separated members, is found in the intermediate wing ribs which lie between the tank baffle ribs of the integral tank section. These have three vertical bracing ties, any one of which can fail without unduly weakening the local structure as a whole. Outboard of the integral tank, the ribs have only two verticals, but each one is itself a duplicated member having an overall channel section built up from two overlapping angles.

The third safeguard against structural fatigue failure, and another form of fail-safe, is the application of a "fail-slow" technique. This is intended to ensure that should any failure occur it does so at such a slow rate that it can be detected during normal inspection procedures and means can be taken to prevent further deterioration of the structure before its strength is endangered.



Although the frames, as assembled here, give the impression of being notched they are not in fact. Outside the outer flange of the frames are inter-stringer brackets and shear plates to take loads from the skin into the frame.

This particular technique—applied by choosing stress levels and materials to give a slow rate of crack propagation—has little weight penalty. It has led to the decision to avoid the use of magnesium in the structure and to the choice of copper-bearing aluminium alloys in preference to the zinc-bearing ones which have better high-strength characteristics at the expense of fatigue properties.

In much the same category comes the provision of crack stoppers in appropriate highly stressed parts of the structure. In the 748, for example, the bottom surface of the wing is made up of four independent spanwise panels so that if a fatigue crack starts it cannot in any case spread readily across the wing.

Similarly, the spar webs in the wing, tailplane and fin structures are split longitudinally to prevent any extensive spread of cracks that may start on the tension side of the web. In the case of the wing spars, the webs are split along a line one-third the way up from the bottom flange; in the case of the tailplane, these units are interchangeable port to starboard and it is necessary for the crack-stopping split to be half way up the spar webs; for the fin, which is equally loaded on each side, the spar web is likewise split along its centre.

Accessibility

Despite these stringent provisions against fatigue failure and the wide applications of the fail-safe philosophy throughout the airframe, it is still essential to ensure that the structure can be thoroughly inspected without much difficulty. To this end, the Avro team has designed the airframe to have almost a profusion of inspection panels which cover, as someone at Chadderton put it, not peep-holes but real man-holes.

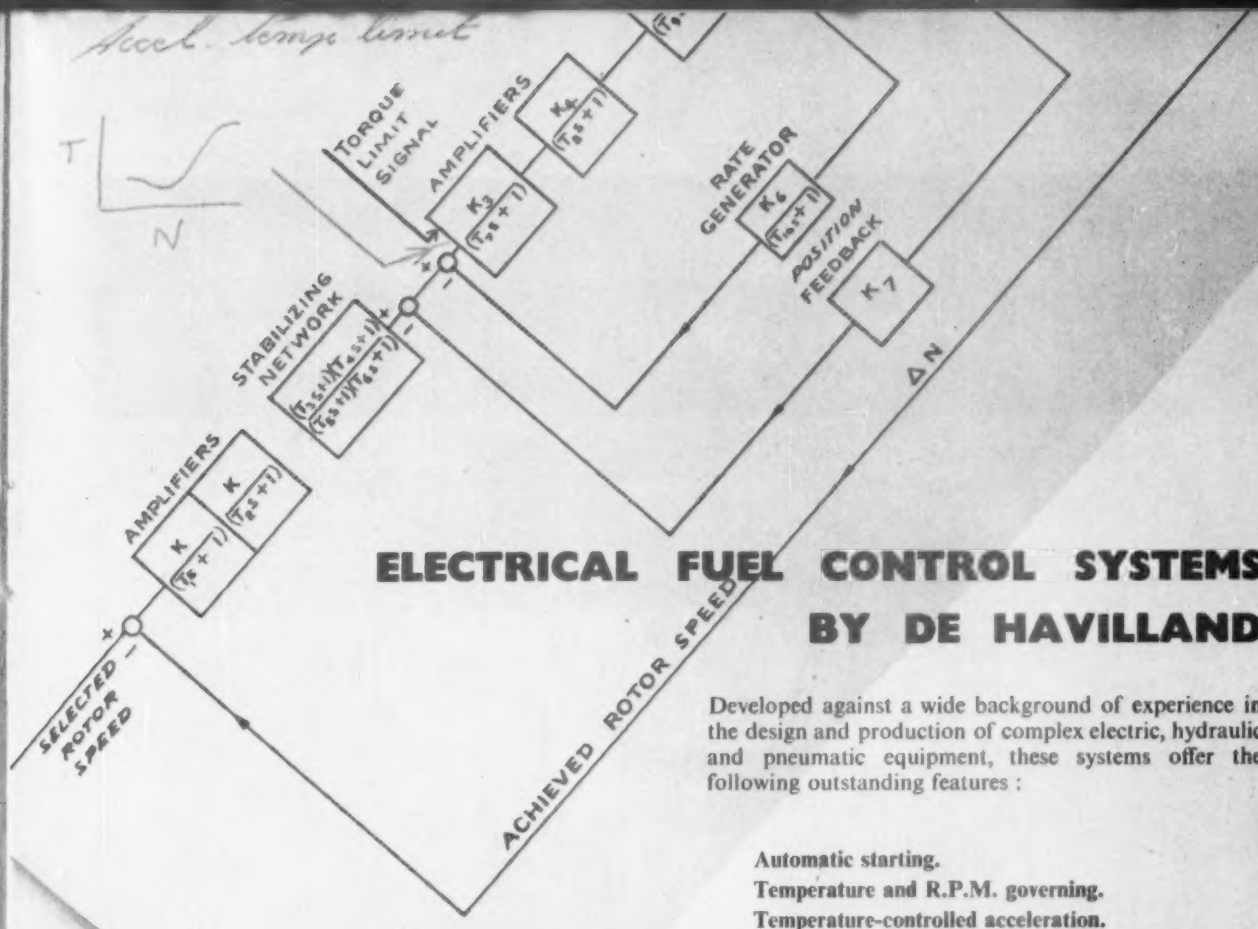
Indeed it is claimed that no part of the airframe is completely boxed in or "blind." This naturally means that a certain amount of additional weight has to be allowed for, but the service that this represents is looked upon as so essential that this extra weight is not really regarded as a penalty.

In the wing structure there are two sizes of inspection hole. Those in the portion of the wing between the root and the outer end of the fuel tank are big enough for an inspector to get his head and shoulders through; outboard of the tank the reduced depth of the wing dictates a smaller type of hole, but even so these are quite big enough for the head to go through.

In the inboard part of the wing the stringers supporting the

(*Continued on page 189*)

This close-up of the front portion of the fuselage in the assembly jig shows the general layout of the structure around the flight deck.



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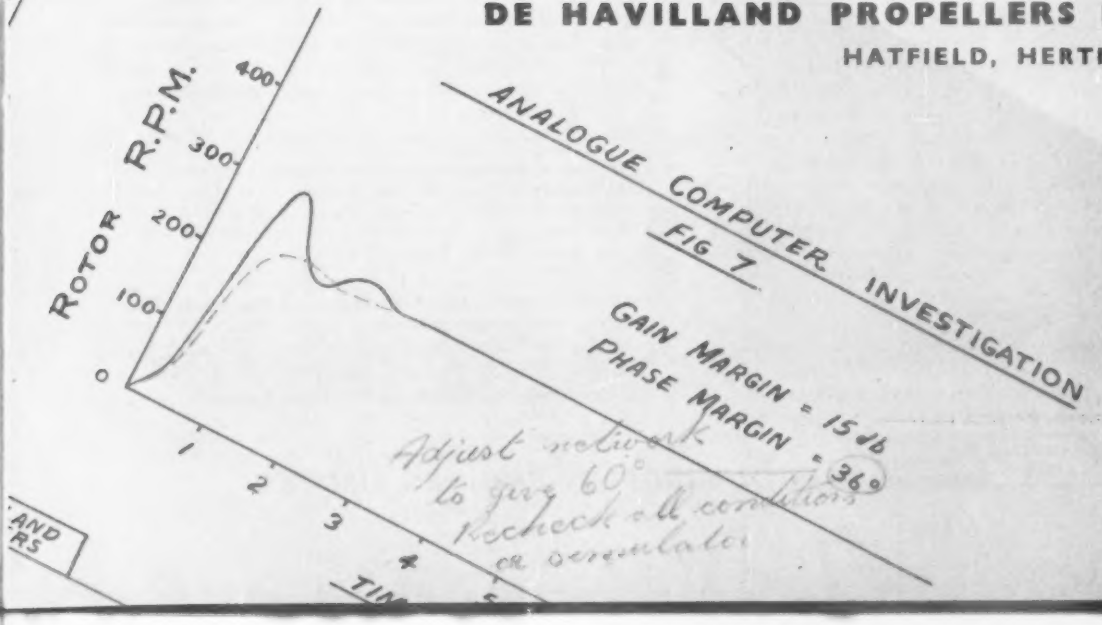
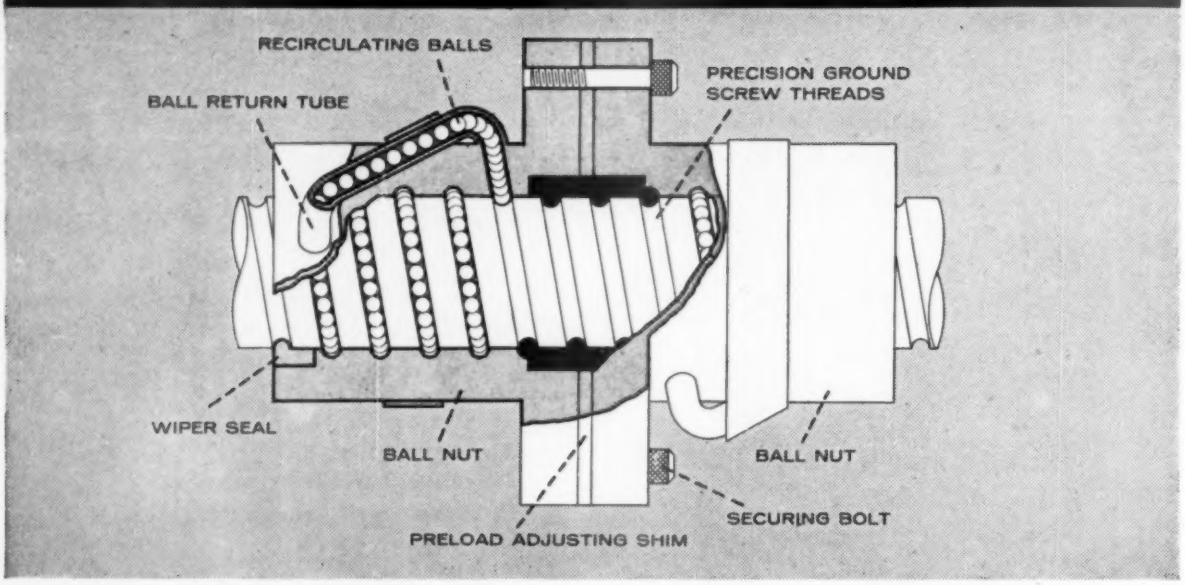


Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



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BRISTOL SIDDELEY ENGINES LIMITED

Details of the Avro 748 . . . .

(*Continued from page 188*)

bottom skin are comparatively bulky members and carry high tension loads. It is necessary, therefore, to preserve some sort of continuity where they are cut away for an inspection hole. This has been accomplished by means of a doubler plate attached to the top flange of the stringers and acting as a local inner skin to carry the stringer and skin loads around the hole.

The access doors are attached to the skin and the internal doubler by a number of closely spaced bolts and lock-nuts. These are not close-tolerance bolts—the door panel is so designed that it does not take any tension loads until the tolerance is taken up by wing deflection.

In the outer wing portion where the stringers are much smaller and the loads correspondingly less the smaller inspection holes simply have skin doubler plates.

An interesting example of design for accessibility is in the fuselage side ribs of the centre-section. These are of the open braced Warren girder type and the central strut is pinned through the top flange and bolted through the bottom one. By removing the bottom bolt this strut can be hinged to one side so that freer access to the centre-section inside the wing but outside the fuselage may be gained.

Structural Continuity

Cut-outs are a notorious source of fatigue cracks and there is bound to be some confliction between the requirements of inspection and accessibility holes and a maximum fatigue safe-life. This conflict, however, can be mitigated by avoiding sudden changes of stress level in the region of the cut-out—which, of course, means preserving continuity of the local structure.

In the 748, the wing/fuselage junction represents the largest cut-out problem; the very nature of the juxtaposition of wing and fuselage makes for healthy stress raising. Here the Avro team has given a considerable amount of thought to the reduction of stress levels and has come up with a solution of which they are specially proud.

At first sight the 748's wing/fuselage junction appears most complicated, but examination shows that a remarkable degree of structural continuity has been established. In effect, the solution has been to pass the fuselage through the wing and the wing through the fuselage in such a way that where either wing or fuselage skin is interrupted, a link across the interruption is provided. The wing skin is, in fact, continuous anyway; the fuselage skin proper is stopped at the centre-section spar webs and at the top wing skin, but is continued within the centre-section wing structure by means of a number of continuity panels.

The fuselage skin is attached to the top of the centre-section skin by an angle member. The three intermediate frames between the main spar frames are bolted to club-foot fittings which pick up with the top flange of the centre-section outer ribs. These ribs have deep top flanges to which are attached fuselage continuity skin panels running fore and aft between the spar webs.

The fuselage structure within the centre-section comprises five such panels located between the centre-section intermediate ribs. The centre panel of the five incorporates four holes to provide for inspection of the bottom wing skin.

Another ingenious application of the philosophies of structural continuity and fail-safe is to be found in the method adopted for mounting the 748's fin on the rear fuselage. The usual practice is to bolt the fin on top of the fuselage through the medium of lugs attached to appropriate frames; in the case of a stressed-skin unit the fin skin is joined to the fuselage skin by fore-and-aft angle members.

The Avro team considers that this is not the ideal method, because in the lower portion of fin the loads tend to be taken mainly by the spars; the skin between them is not doing as much work as it should, and a fail-safe attachment structure may not be obtained. Thus, in the 748 the fin structure has been extended down into the fuselage so that the loads can be taken out at four points—two on the fuselage and two lower down on the rear pressure bulkhead and a rear frame. By this means, the overall fail-safe characteristic of the fin is maintained and there is no need to attempt to diffuse the bending loads out of the fin skin into the fuselage structure via corner flanges.

Of the fin mounting attachments, the top two and the bottom rear one are of the idle stand-by type used for the tailplane attachment. This could not be used in the case of the bottom forward fin attachment to the pressure bulkhead, as it has to incorporate a swinging link to allow for movement of the bulkhead diaphragm under pressure loads.

In the wing, structural continuity in the region of the undercarriage and engine mountings is preserved by locating the actual attachment fittings above and below the wing outside the skin so that the torsion box is unbroken. Within the wing in this area are two sturdy ribs of which the flanges are outside the wing contour while the bracing structure is inside it; the skin is trapped between the flange and bracing members and the joint made by bolts. To these external rib flanges are attached forgings to provide main pick-up points for the engine mounting above the wing and the undercarriage below it.

Because the undercarriage can be kept short as a result of mounting the engines above the wing, it would, if hinged about a point on the rear spar, need a wheel-well cut-out in the wing torsion box. This has been avoided by moving the hinge point forward so that, when retracted, the wheel lies ahead of the front spar.

Structural Simplicity

As we have already mentioned, low first cost and ease of repair with limited equipment have been prime considerations in the design of the 748. For this reason big forgings and integrally machined skin panels have been avoided. Also, although the Avro team have long been a firm protagonist of honeycomb-stabilized sandwich panels, these have not been used in the 748 on the score of difficulty of inspecting their interior and of their repair away from base, if damaged.

This overall philosophy has led to the extensive use of sheet material, simple rolled or folded sections, and some extended channel and T-section members. The only large forgings to be found in the 748 are the undercarriage mounting fittings and the wing/fuselage junction fittings. All attachments are by rivets or bolts; no metal-to-metal bonding or welding is used.

The general fuselage structure is the skin-upon-stringer-upon-frame type that has long been favoured by Avro. Use of this form of structure can in fact be regarded as a crack limiting device in itself for the more usual notched type of frame can be a crack initiator. In the 748, then, the frames are unnotched and continuous stringers are riveted on the outside of their periphery flanges by small brackets.

Shear loads from the skin are taken into the frames by small intercostal shear angle plates riveted to the frame webs between the stringer positions. Each alternate bracket is extended inwards on the frame so that half of these plates stiffen the frames against buckling and distortion.

In accordance with the requirements for structural simplicity, the 748's pressure bulkheads are flat, instead of dished, units and have vertical stiffening members on one face and horizontal stiffeners on the other. The tension flanges of these bulkhead members are duplicated units made up of simple back-to-back angles to provide a fail-safe characteristic.

Avoiding handed components is another important factor in the overall operating economy of an aeroplane of this sort. For this the 748's engines; propellers; complete "power-egg" back to the firewall; engine mountings, on top of the wing; main undercarriage units; tailplane halves; and elevators, are all interchangeable port to starboard. Interchangeability between aircraft is also ensured by close-tolerance jig-controlled manufacture. Finally, on the score of repair and interchangeability, it is worth noting that the big freight door of the 748 enables any major airframe component—with the exception of a wing—to be loaded into the fuselage for transport.

An interior view of the wing centre-section looking aft. The transverse curved panels visible at the bottom are the fuselage continuity panels to complete the fuselage structure within the wing box.

POWERPLANT SURVEY

1

In this first article of our survey of powerplant trends, PROF. A. G. SMITH, B.Sc., D.I.C., A.F.R.Ae.S., *Professor of Aircraft Propulsion at The College of Aeronautics, discusses some of the "back-room" work behind recent developments.*

THERE has been little mystery about the thermodynamics of turbine engines for two decades or more; anybody with a slide rule could produce the fundamental curves shown in Figs. 1 and 2, which apply to turbojets under sea-level static conditions, any day in the past 20 years. The general picture is well known: the specific fuel consumption of the turbojet decreases as the pressure ratio of the compressor is put up and increases as the flame temperature is put up. The specific thrust, however, which is a measure of the thrust produced by a given size of engine, goes up rapidly with flame temperature.

In 1944, the turbine engine was the Whittle-type jet. Its centrifugal compressor gave about 4.2 : 1 pressure ratio at about 75% compression efficiency. Its flame temperature was around 800° C. and its specific fuel consumption on the test-bed, around 1.05 lb. thrust/hr./lb. fuel. The performance of the Whittle W2/700 is marked on Fig. 1—not very accurately because the efficiency of the Whittle compressor did not come in the 87-92% efficiency range for which the curve is drawn.

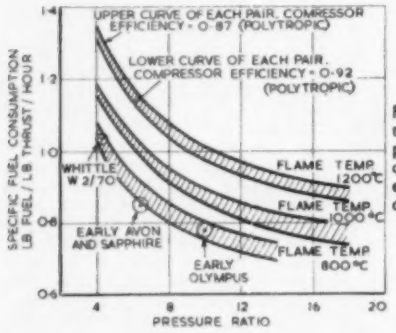

UPPER CURVE OF EACH PAIR, COMPRESSOR EFFICIENCY = 0·87 (POLYTROPIC)
LOWER CURVE OF EACH PAIR, COMPRESSOR EFFICIENCY = 0·92 (POLYTROPIC)
SPECIFIC FUEL CONSUMPTION LB FUEL / LB THRUST / HOUR
WHITTLE W 2/700
FLAME TEMP. 1200°C
FLAME TEMP. 1000 °C
FLAME TEMP. 800 °C
EARLY AVON AND SAPPHIRE
EARLY OLYMPUS
PRESSURE RATIO

Fig. 1. Effect of flame temperature, pressure ratio and compressor efficiency on specific fuel consumption (sea-level static).

If one looks at the Whittle engine on these curves, it will be seen that:—

(a) Both s.f.c. *and* specific thrust improve if compressor efficiency is put up. The same holds for turbine efficiency.

(b) If pressure ratio is put up from the Whittle value, both s.f.c. and specific thrust will be improved.

(c) If flame temperature is put up, s.f.c. increases, but specific thrust goes up.

These conclusions, first drawn many years ago, pointed the way jet engines should go. First, compressor and turbine efficiencies should be raised. The Whittle engine was stuck with a compressor efficiency below the 80% mark because Mach numbers were already very high at entry to both impeller and diffuser.

It might have been possible to put up the pressure ratio a little, though the Whittle impeller was already running at slightly over 1,500 ft./sec. tip speed, and stressing and vibration difficulties would probably have been severe at higher speeds. The increased pressure ratio would anyway have been obtained at the expense of decreased efficiency.

Even whilst the first Whittle engine was flying, there existed compressors of superior efficiency. These were the axial compressors; their pressure ratio seemed to have no limit, as more and more stages could be added. They seemed at first to be heavier than centrifugal compressors; but mechanical designers have a habit of making theoretical weight prediction look silly.

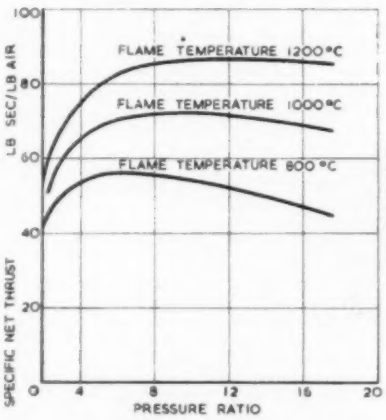


Fig. 2. Effect of flame temperature and pressure ratio on specific thrust (sea-level static). Compressor efficiency 0.87 polytropic.

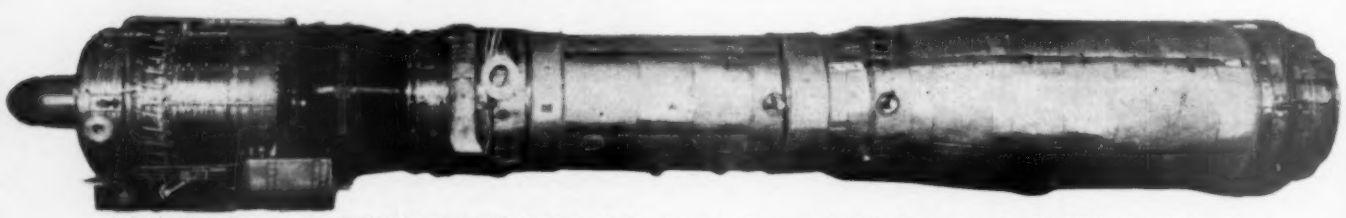
and axial engines soon showed better thrust/weight ratios than the most highly developed centrifugals.

A generation of axial turbojets (Avons and Sapphires) grew up with a pressure ratio around 7 : 1 and a specific fuel consumption on the test-bed of around 0.84. Obviously improvements in specific fuel consumption and specific thrust were still to come from further increases in pressure ratio. Here, an obstacle appeared in the difficulty of achieving more than about 7 : 1 pressure ratio on a single spool.

Single-spool axial compressors of 12 : 1 pressure ratio have been built and run at high efficiency. But they suffer from the painful malady of mismatching.

Compressors are designed for roughly the same axial velocity all through from front to back. This means that the annulus area must be less at the back than at the front, because the air is more dense at the back end (5 or 6 times more dense in the case of a 12 : 1 compressor). The compressor is only properly matched from front to rear at the density ratio for which it is designed.

If the compressor is run at low speed (suppose it is so low that there is no density increase) then the air velocities cannot be correct everywhere; if axial velocity were right at the front end it would be five times too high at the back end. If it were right at the back end it would be five times too small at the front end.



A de Havilland Gyron Junior DGJ10 complete with jet pipe and after-burner—the powerplant for the supersonic Bristol 188 research aircraft.

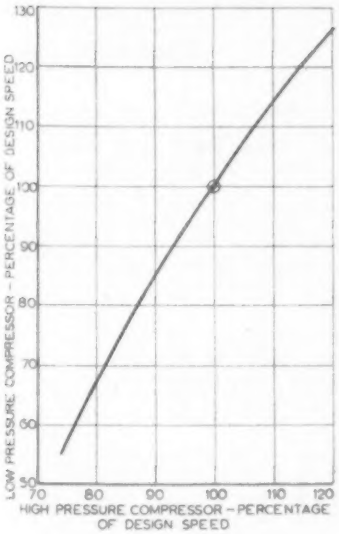


Fig. 3. Variation of low-pressure compressor speed with high-pressure compressor speed on two-spool jet of about 12 : 1 pressure ratio.

Actually, at part speed a compressor compromises and runs with axial velocities too low, correct, and too high respectively at front, middle and back. This leads to trouble at the front end. The velocity triangles make the incidence become very positive on the blades and they stall, much the same as a wing stalling.

This might not be expected to matter very much, although there would be a loss of efficiency. However, it does matter, because as soon as a few blades stall and lose their lift, some of the air already compressed takes the opportunity of escaping out of the front of the compressor. The compressor regurgitates in a complicated manner, and a band of reversed, or at any rate very disturbed, flow occurs in the first few stages. This band rotates at about half rotor speed.

In passing through the disturbed region, both rotor and stator blades get shocking treatment. Large cyclic forces are imposed on the blades and, if the excitation frequency coincides with a vulnerable natural frequency, blades are liable to break off through fatigue failure and give the rest of the compressor a short haircut. Even ignoring the harsh treatment of the front end blades at low compressor speeds, the concomitant low compressor efficiency would lead to an engine with a high starting speed.

There are three ways of pandering to the queasy digestion of the high-pressure-ratio compressor. The first, obviously, is to blow off air at the compressor midriff, thus satisfying the need of the compressor to have more air through its front end. This solution was adopted for various marks of Avon.

The second is to put the front end of the compressor into fine pitch (pitch used in the propeller sense) for conditions when the air flow there is less than that with which the compressor is happy. This is done by "variable stagger stators."

This solution has been adopted particularly on American engines; the General Electric J79 turbojet of 12 : 1 P.R., for example, has variable stagger on the first six of its 14 stator rows and the T58 of 8.3 : 1 P.R. has variable stagger on the first three of its 11 stages. The variable stagger is put only on the stators—it is as near impossible as anything to put it on high-speed rotors. British designers haven't gone so far, although the de Havilland Gyron Junior has variable stagger on its intake guide vanes and first-row stators.

The third solution, the one favoured in this country, is to go to the two-spool engine. This type of layout has the desirable property that as the engine is throttled, the low-pressure shaft speed falls off more quickly than the high-pressure shaft speed (Fig. 3). When the H.P. shaft speed has fallen off to 80% of design the L.P. shaft speed has fallen off to about 67% of design. This is exactly what the compressor needs since the low-pressure compressor speed now suits the reduced volume flow of air.

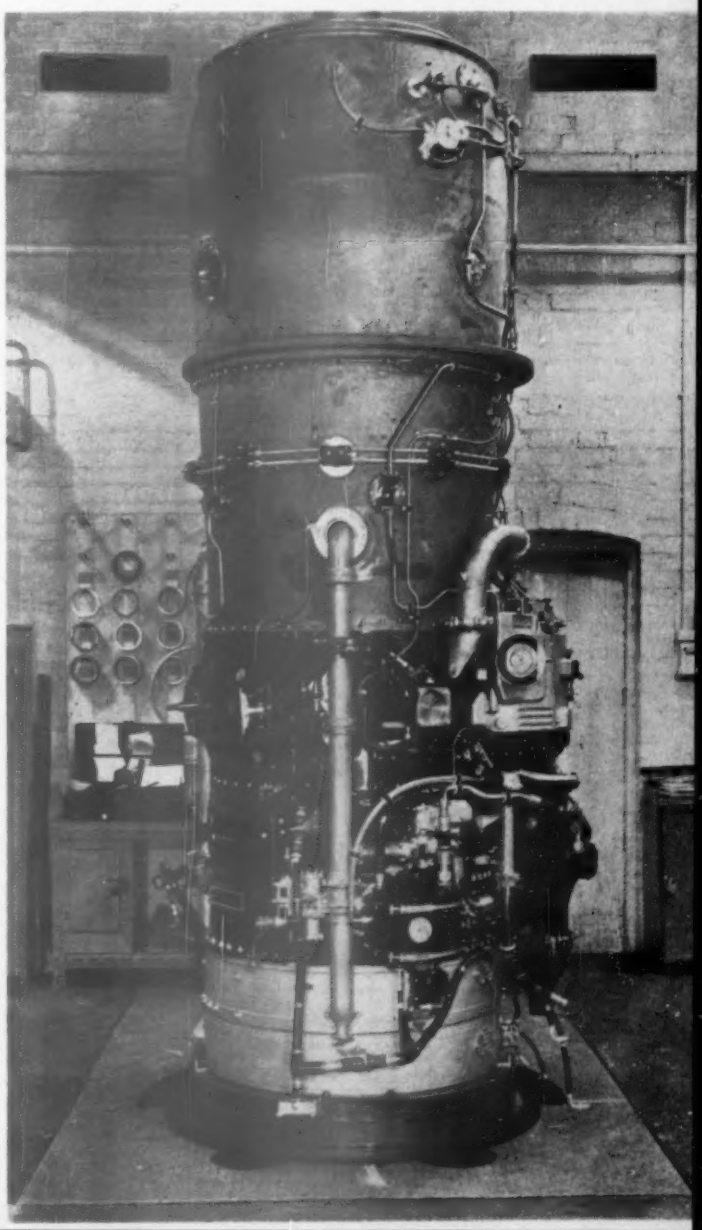
The mismatching trouble still exists to a reduced extent, but anyway pressure ratios of up to about 16 : 1 could be designed for; and 12 or 13 : 1 have been achieved on the Olympus jet engine. Approximate positions of the Avon, Sapphire and Olympus engines have been plotted on Fig. 1. It is possible to get very low s.f.c. by running at low flame temperature, and an Olympus engine delivered a test-bed s.f.c. of 0.68 in 1958.

Along with the higher pressure ratios dictated by thermodynamics, somewhat higher efficiencies, pressure rises per stage, and swallowing capacities have been achieved by designers. It is rash to make the efficiency claim since a glance at achieved efficiencies over the years (Fig. 4) shows that the best compressor efficiency claimed was around 90% in 1942, and the value cannot be much above this now. At 90%, pure skin friction is accounting for most of the inefficiency, and short of going to boundary-layer suction on the blades (which would be a real design problem) there cannot be much more improvement to come.

What the designer has done is to keep efficiencies high whilst at the same time improving the stage pressure rise (Fig. 5) and the swallowing capacity. The last two improvements tend to be at the expense of the first, so the aerodynamic merit of compressors has improved. The picture of the interaction of these three quantities is something like this:—

Increased pressure rise per stage is obtained largely by increasing blade speeds. At higher blade speeds the interaction of shockwaves with blade boundary-layer tends to give flow separation and reduce efficiency. A careful look at sectioned engines at the S.B.A.C. Show gives the impression that designers have put up critical Mach numbers by going to sharp-nosed blade sections instead of the earlier aerofoil-type section. Thus somewhat higher blade speeds have been possible.

On the first stage of the compressor, pressure rise can be exchanged for swallowing capacity to a certain extent. This is because a large swallowing capacity can be achieved by a large flow area (i.e., a low hub diameter) or by high axial velocity, or by both. A low hub diameter means a low blade speed at the hub, and hence a small pressure rise at the hub;



A Rolls-Royce Conway by-pass turbojet on a vertical assembly stand at Derby.

Powerplant Survey . . . .

therefore the designer has to accept a smaller pressure rise for the stage, as it is not possible to design for a larger pressure rise at the tip than at the hub.

The investigation of this sort of thing has proceeded via solution of the equation of motion of air; more knowledge of the performance of cascades of blades; improved blade sections; and, above all, a vast amount of test work with compressors.

Mere aerodynamics is not the only thing the compressor designer has to cope with; his compressors must not break, and they must be light. When the first axial engines were made (for example, the Metropolitan-Vickers F2) they were heavier than the corresponding Whittle jets. Drum construction was used for the rotor. Development trends were towards disc-type construction, and the thinning of everything.

As blade speeds increased and hub/tip ratios decreased, the problems of blade vibration became more acute. Research revealed the mechanical modes of vibration and the aerodynamic exciting forces. If the flow through the compressor is a little lop-sided (and it is easy for intakes to impose this on the compressor), then a periodic force will be applied which can put energy into a blade whose natural frequency is at compressor speed or a multiple of it. Rotating stall cells provide another set of exciting frequencies, and wakes from previous blade rows or intake spiders yet another.

The designer cannot avoid his blades resonating with some or other of the exciting forces—this is as impossible as walking

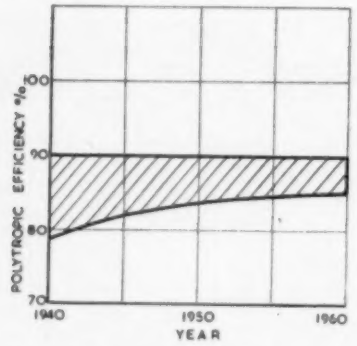


Fig. 4. Trend of axial compressor efficiencies most reported—efficiencies have fallen in the hatched area.

in a straight line through a forest without bumping into trees. So the problem has been to avoid the deadlier sorts of excitation and to strengthen blades to withstand those that cannot be avoided. Nature is not completely malicious in this matter—there is an aerodynamic damping of vibrating blades analogous to the damping in roll of an aircraft wing; and this damping, together with material damping of the blades and root damping (energy absorption by friction at the root fixing), makes some solution of the vibration problem possible.

External excitation is not the only mode of energy input to blades, however—blades can self-excite in much the same way as aircraft wings flutter. "Choking flutter" can occur at the high axial velocities obtaining at the back end of the compressor at part speed. On blades of high aspect ratio it can be deadly, but fortunately back end stages have low aspect ratio. "Critical Mach number flutter" occurs when both the Mach numbers and incidences are somewhat above design values.

No full theory of blade vibration has ever been achieved, and not for want of trying. With around 2,000 blades in a compressor—fatigue failure of any one of which may necessitate shut down in flight—the problem has not been ignored. At one time it was thought that putting an adequate factor on the steady stress due to aerodynamic loads would avoid fatigue failures. That is, it was believed that vibratory stresses were proportional to calculated steady stresses.

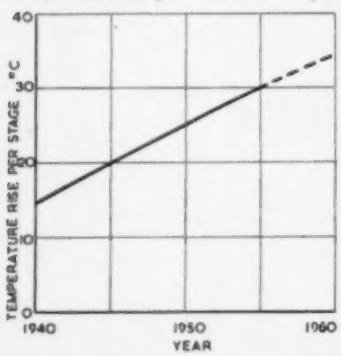


Fig. 5. Trend in stage temperature rise of the most highly loaded axial compressors, brought about by increases in stage pressure rise.

It turned out that this approach was unduly restrictive. There is some evidence that increases in vibratory stresses are proportional to air density. On the whole, the approach to the problem has had to be a painstaking watch on the occurrence of important vibrations in engines, coupled with design changes in blade shape or material to ameliorate dangerous stresses as they were found.

The thermodynamic picture presented in Figs. 1 and 2 (for sea-level static conditions) is a fairly good guide to the performance "driving forces" acting on the designer so far as jets for high-speed flight are concerned as well as for the test-bed. Even at Mach 2 the position is similar; improved s.f.c. with higher

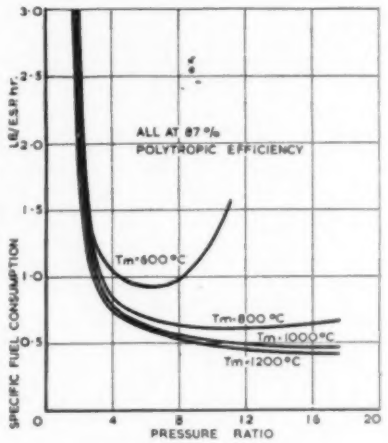


Fig. 6. Specific fuel consumption for propeller turbines—at standard sea-level static conditions.

pressure ratios, s.t. improving with flame temperature, but s.f.c. worsening with flame temperature.

Turboprops are different. Flame temperature does not act against efficiency, but for it, as indicated in Figs. 6 and 7. Thus on the shaft-power engine the paramount need, since the early days, has been for increase of flame temperature.

Flame temperatures have gone up about 250° C. since Whittle's engines with the improvement of materials (Fig. 8); the adoption of blade cooling; and the improvement of combustion chambers to give highest flame temperatures where the blades are least stressed, i.e., near the tips. The Wartime German turbines employed blade cooling in fabricated hollow blades; the cooling was rudimentary, quite low cooling air velocities on the inside of the blades being employed, and the air directed on the part of the blade needing it by inserts. Cooling obtainable with this type was not great—the air could not be brought into good enough contact with the blades to extract much heat.

Work at the N.G.T.E. and at companies since the War has been directed at getting a much larger internal cooling area than can be achieved with simple hollow blades. The first type of air-cooled blade tried at N.G.T.E. (water cooling was rejected for reasons of complication in plumbing) had a large number (36) of small holes, 0.030 in. in diameter, stretching the length of the blades.

Drilling such holes was no proposition, so the blades were made by sintering Vitallium with cadmium wires to form the hub, the cadmium being boiled off subsequently. Cascade tests revealed a reasonable cooling performance and similar blades were run at flame temperatures of more than 1,200° C.

The benefits from turbine cooling are not straightforward: the cooling air has to be paid for (and the price is higher on turboprops than on turbojets), blade centrifugal stresses tend to be higher on cooled blades anyway, as they cannot be tapered so much as uncooled blades, and it may be that aerodynamic efficiency is compromised by the rather fat sections which are easier to cool than conventional sections. Fig. 9 shows the cooling performance of a particular type of extruded blade made by Henry Wiggin, Ltd.

The materials man has been working wonders at the same time as turbine cooling has advanced. Fig. 8 shows the improvement in the Nimonic series of alloys—something of the order of 10° C. increase per year with the promise of more to come in the next few years. There must be some sort of limit to the development of metals for blades, and the ceramic and

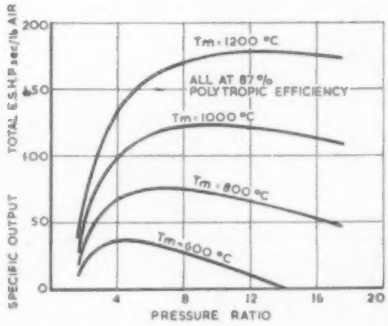


Fig. 7. Specific outputs for propeller turbine—standard sea level, static conditions.

cermet materials are kept under review. They tend to suffer from sensitivity to thermal shock.

Aerodynamic efficiency of the turbine is even more important than that of the compressor in the turboprop: simply because the turbine power is the bigger and, therefore, there is more to be lost by inefficiency. The turbine has two fundamental aerodynamic advantages over the compressor; the velocity of sound is higher in its working gas, and there is a pressure drop instead of a pressure rise in passing through its stages.

The first fact permits higher gas velocities before shock-wave effects start nibbling at efficiency, and the second permits higher lift coefficients to be developed on the blade. The two effects together enable seven or eight times the power to be got out of a turbine stage than can be put into a compressor stage. In the jet stone-age, the designer went too far in loading his turbine, partly to avoid multi-stage turbines and lost efficiency. Later he unloaded a little and improved the efficiency (Fig. 10).

This last sentence is a somewhat inadequate description of a process involving the rig testing of hundreds of different turbine shapes, the theoretical analysis of gas flow by the most advanced techniques, and the most lucid tracking of the elusive percents. It seems probable that there is still something to come on turbine efficiency. It may be that the "unloading" tendency mentioned above will be reversed for ultra-light lifting engines.

The life of turbine blades is limited ultimately by creep of the blade materials and it has been found to be important to avoid unwanted additional stresses arising from centrifugal bending moment. This last-named is brought about by the blade centre of gravity not lying accurately radially outward from the blade root; a few thousandths of an inch "lean" can apply stresses of tons/sq. in. at the root section due to centrifugal bending moments.

It is one of the elementary facts of propulsion life that the engine receives no credit for the kinetic energy it leaves behind in the atmosphere after it has gone by. This kinetic energy is a loss and represents energy which might have been put into pushing the aeroplane. It is worse than a loss, it is a positive harm, since part of the kinetic energy appears as jet noise.

The smallest loss for a given thrust is obtained by propelling backwards the largest possible amount of gas at the lowest possible speed. This is why the propeller turbine is a more efficient propulsion device than the jet at low speeds. This happens in spite of the fact that the slip-stream kinetic energy gets there via a turbine, a reduction gear and a propeller, whilst the jet kinetic energy gets there via a highly efficient propelling nozzle. At high aircraft speeds, the propeller efficiency falls off due to high Mach numbers near the tips.

There is no such effect on the jet engine where, if anything, the Mach numbers tend to decrease due to increasing temperature at compressor intake and, therefore, increasing velocity of sound there. However, it is clear that the best jet engine is suffering in s.f.c. by flame temperature whilst the turboprop, which gets more and more economical the higher the flame temperature, cannot propel an aircraft at high speeds.

The by-pass engine comes in here. Because it uses its available power on the expansion side of the cycle to drive both a hot jet and a cold jet, its propulsive efficiency is higher than that of the turbojet, whilst it does not suffer the aircraft speed limitation of the turboprop. Thermodynamically, the turboprop is a by-pass engine with a by-pass ratio of 200-300.

The idea of the by-pass or turbofan engine is old—indeed Whittle built one with reheat which was to go into the Miles M52 aircraft. The engine was called the No. 4 Thrust augmenter and had two-tier turbine blades.

The by-pass engine differs from the turbofan in mixing its by-pass air with the hot jet just after the turbine, whilst the turbofan keeps the two streams separate right up to the propelling nozzle. This mixing of the hot and cold air puts an extra knob on the thermodynamic jig-saw puzzle in that the by-pass air pressure must be the same as turbine exit pressure, whereas the turbofan engine does not have this requirement.

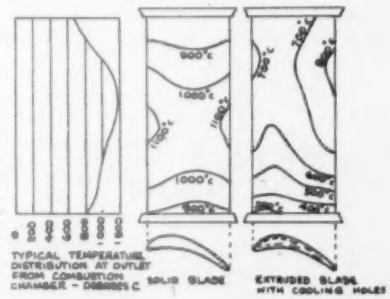


Fig. 9. Temperature distribution in cooled and uncooled turbine blades.

Some of the trends in engine design can be seen within a simple thermodynamic framework. Others cannot. This is because an engine cannot be assessed independently of the aircraft using it. The fact that efficiency is more important than weight for a long duration flight is an old chestnut.

Suppose that the advanced project engineer is thinking about engines for supersonic flight. In general, he can bring down s.f.c. at the expense of specific weight; weight increasing either with compression ratio or with by-pass ratio, whilst s.f.c. goes down. If the cruise flight is of one hour's duration, the minimum (engine+fuel) weight will be at, say, the by-pass ratio at which specific weight is increasing as rapidly as s.f.c. is decreasing. If the cruise flight were of four hours' duration, the minimum (engine+fuel) weight would be at the by-pass ratio where specific weight was increasing four times as quickly as s.f.c. was decreasing.

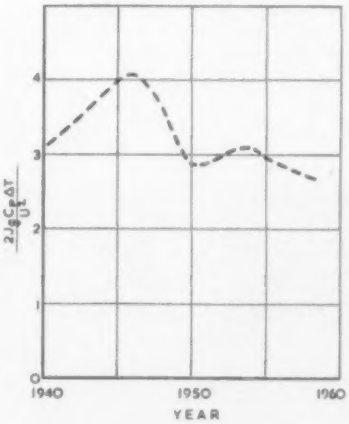


Fig. 10. Approximate trend of turbine blade loading.

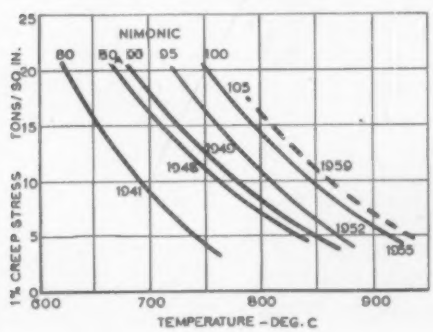


Fig. 8. Trend in Nimonic alloys.

High supersonic cruise speeds mean short durations, which mean in turn a greater importance of light engines as compared with good fuel consumption. Light engines mean low mechanical compression ratios (i.e., pressure ratio in the compressor) and this tendency is reinforced by the fact that from an s.f.c. point of view high pressure ratios are not needed. This is because the intake provides most of the compression in the Mach 2 to 3 range.

Powerplant Survey—2 . . . .

Ducted Fans for VTOL and STOL Aircraft

By Neville Quinn, B.Sc., A.F.R.Ae.S.*

ADVANTAGES of vertical take-off and landing have long been recognized, but it is only recently that developments in gas-turbine engine technology have made possible turbine engines of sufficiently high thrust/weight ratio to make jet-propelled vertical take-off aircraft practical.

The helicopter, indeed, offers VTOL characteristics but, although this type of aircraft represents the most efficient way so far employed to achieve vertical lift, it suffers from serious limitations which are inherent in the rotor system. These arise basically from the fact that as the helicopter approaches its maximum speed, the retreating rotor blade is approaching its stalling angle of incidence, while the advancing blade on the other side of the aircraft is approaching its critical Mach number. Consequently, the helicopter has a limiting speed in the region of 200 m.p.h. which cannot be exceeded.

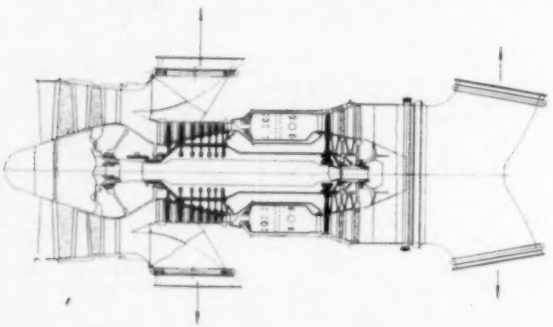


Fig. 1. This engine will provide lift for vertical take-off and landing, and propulsive thrust for normal flight. Conventional horizontal installation is possible.

The type of jet-lift gas-turbine engine most suitable for a particular VTOL aircraft varies according to the job which the aircraft is required to do. The engine installation for a long-range VTOL civil transport, for example, would be unlikely to be the same as that for an aerial crane.

A type of aircraft in which a great deal of interest has been taken recently is the low-altitude strike machine intended for the close support of armed forces on the ground. This represents another application where VTOL characteristics can be used with advantage, since they enable the aircraft to operate from almost any space having a flat surface, as compared with the relatively long runways or prepared strips required by conventional aircraft.

The two main categories in which VTOL is likely to be applied initially are the small high-performance single-seater aircraft, including fighters and ground attack machines, and the larger multi-seater aircraft, which may be military or civil.

For small high-performance military aircraft there are considerable advantages in the use of a single engine and this must, therefore, be capable of the combined duty both of providing lift at take-off and landing and of providing propulsive thrust in normal flight. Such a powerplant is shown in Fig. 1.

The fan unit is mounted at the front of the engine, and supercharges the gas-generator or high-compression section of the engine, which might be basically similar to an existing turbojet such as the Orpheus. The ducted fan unit is driven by an independent two-stage turbine downstream of the turbine of the gas-generator section through an independent shaft, running concentrically within the rotor of the gas-generator.

One of the new features of this engine is the simple way in which the jet is deflected, either downward to give vertical lift, or horizontally rearward to provide thrust, or in any angular position between the two in order to give a combination of lift and thrust. It is an interesting result of Pythagoras' Theorem that if the jet is deflected at an angle of 60°, it is possible—assuming the total thrust is 10,000 lb.—to obtain a component of 5,000 lb. in the horizontal direction and one of 8,666 lb. in the vertical direction.

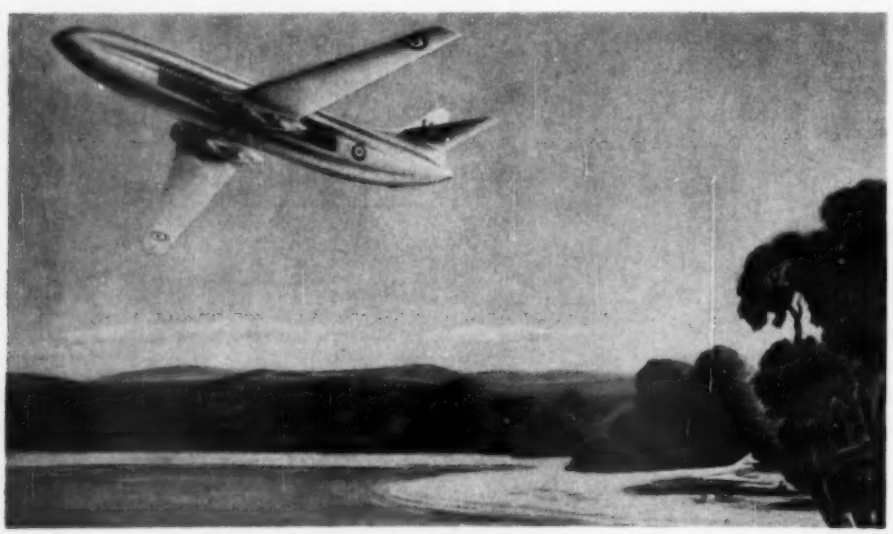
The air flow from the ducted fan is bifurcated into two ducts one on each side of the engine which terminate in directionally controlled nozzles. Similarly, the exhaust jet is bifurcated and terminates in a pair of directionally controlled nozzles.

It has in recent years become necessary to treat the engine/airframe combination as a whole, rather than to treat the engine in isolation. This is essential with VTOL/STOL aircraft, and the whole combination must be carefully designed to suit the specific requirement. It is no longer possible to claim that an engine installation which is best for one type of aircraft will necessarily also be the optimum for a different type.

Studies of a small single-seater strike aircraft indicate that the type of powerplant shown produces a higher overall

(*Continued on page 195*)

* Assistant chief engineer, Bristol Siddeley Engines, Ltd.



VTOL TRANSPORT.—For an aircraft of this type all engines must be able to give their full thrust as lift. Here two podded engines give lift for take-off and landing, and thrust in level flight. Four vertically mounted engines in the fuselage provide the remaining lift thrust which is needed.

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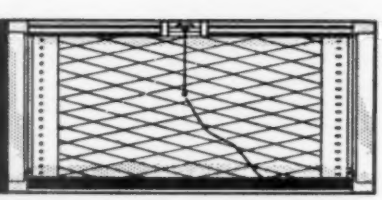
The IFALPA delegate speaking to the ICAO Special Meeting, Montreal, February 1959

I should like to describe what we have been able to do using Radar for departures. Four aircraft taxi out at the same time. They are fully loaded, it is a hot night so they have an immediate problem. After take-off Departure Control wants immediate contact so we give them a call. Number 2 aircraft takes off two minutes later, and receives the same clearance until he picks up Radar Departure, who say " Turn left heading 050° "—now this is into inbound traffic, which means he will require continuous attention from Control to make sure he picks his way safely through the incoming traffic. Aircraft number 3, two minutes later, same as before, except when he picks up Radar Control, The Controller says " hold 4,000 ft. heading 130°." (he has vectored him off so as to clear the way for aircraft number 4). Aircraft number 4 receives the same departure, but he is told to hold 3,000 ft., and the Radar Controller's attention will also be especially directed towards him because he is bucking the flow of traffic in a place where he does not properly belong.

With regard to the overall achievement, we have now vectored four aircraft into a single airway. Only one of them has achieved the altitude he wanted, and unfortunately he will have to come down through the altitude of the others. Radar is a marvellous device, and it has solved many of our problems, but it is *not* a navigational aid. An area coverage system would not solve every problem, but it would provide the capability of outbound tracks that would take us immediately out of the area from whence discrete tracks could be drawn giving lateral separation of a safe order. This is a problem which is incidental to the use of single track airways, and we feel **it can be solved by lateral separation which should be made available through pictorial presentation coupled with area coverage.**

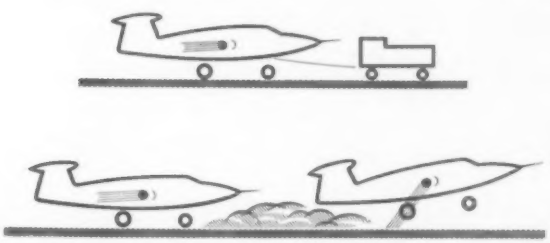
THE DECCA NAVIGATOR



THE NAVIGATION SYSTEM FOR THE JET AGE

THE DECCA NAVIGATOR COMPANY LIMITED LONDON

Powerplant Survey . . . .



LIFT-THRUST ENGINE.—These diagrams show how lift-thrust engines can be started and the aircraft taxied with jets pointing backwards. For STOL operation the aircraft can start with jets directed backwards; on take-off they can be directed downwards, giving a lift component and preventing debris being drawn into the intake.

(*Continued from page 194*)

aircraft performance than any other engine configuration. In addition, this type of powerplant has many practical advantages of great importance, one of which is that it is mounted horizontally in the aircraft in a manner which is entirely conventional in every respect except for the controllable nozzles. No new air-intake problems are encountered.

Secondly, the aircraft can always be operated from normal runways as a conventional aircraft with the nozzles pointing to the rear. This will greatly facilitate training on the new type; and it also enables the aircraft to be ferried for long distances, since the weight at which the aircraft can take off in the conventional manner is very much greater than in the case of vertical take-off, enabling a heavy overload of fuel to be carried.

For short take-offs (in, say, 200 yards) the aircraft can be accelerated with the jets directed rearwards, and then they can rapidly be deflected downward to, say, 60°, when 87% of the thrust of the engine will be given in lift and 50% will still be available for horizontal acceleration. In such cases the aircraft will clearly blow debris behind, well away from its intakes.

Even for vertical take-off the engine can be started and opened up to full power with the jets exhausting horizontally. The nozzles can then rapidly be deflected downwards, to give the minimum time for ground erosion by the jet and for debris to be blown around, with consequent risk of damage to the aircraft, particularly as a result of debris being drawn into the intakes. Moreover, the engine can be run up and the aircraft taxied with the jets directed horizontally rearwards.

The fact that such an aircraft, designed for both VTOL and STOL, has only one engine will enable the maintenance and logistic problems arising from operation out of widely dispersed fields to be kept to a minimum.

The choice of a ducted-fan engine, with four jet effluxes, simplifies the task of ensuring that the resultant thrust passes through the centre of gravity; this can be achieved for each direction of the jet and the engine centre of gravity at the same time arranged to be close to that of the aircraft. In addition, this type of engine possesses a very high thrust/weight ratio and has a number of incidental but useful advantages.

Its ratio of take-off thrust to cruise thrust is higher than with normal turbojets, which fits in admirably with the need to achieve the maximum possible thrust for vertical take-off. It has a lower fuel consumption than the normal turbojet, resulting in greater range. The ducted fan engine gives the aircraft a high-thrust reserve, and thus a high rate of climb.

Moreover, the cooler and lower-velocity jets—the fan efflux is, of course, merely compressed air, and the turbine exhaust is at a temperature and velocity more comparable with that of a turboprop than a turbojet—reduce ground erosion.

Many of these advantages also apply to the slow-speed wingless vehicle, or "flying crane," though this machine will, of course, be limited to vertical take-off and landing.

For larger aircraft such as transports, bombers, reconnaissance machines, etc., a number of power units is required. This is particularly the case where the requirement involves providing for engine failure at take-off. The great problem in a large VTOL aircraft is to achieve the take-off thrust, which must be somewhat greater than the weight of the aircraft; it follows from this that all the engines should be capable of giving their full power in the form of lift.

In other words, engines used solely for propulsion are undesirable. When the transition from vertical take-off to normal flight has been achieved, then most of the engines can be shut down, since the cruising thrust required for best range is less than one-tenth of the weight of the aircraft.

It is, therefore, desirable to have a number of engines, say two, which are used both for lifting during take-off and for propulsion during cruising flight, together with a number of specialized lifting engines used only during take-off and landing. In one arrangement a transport aircraft has two BE 53 lift/thrust ducted-fan engines installed in pods, one under each wing, and four specialized lift engines installed in the fuselage. Again it must be emphasized that the optimum arrangement depends on the requirement in any particular case.

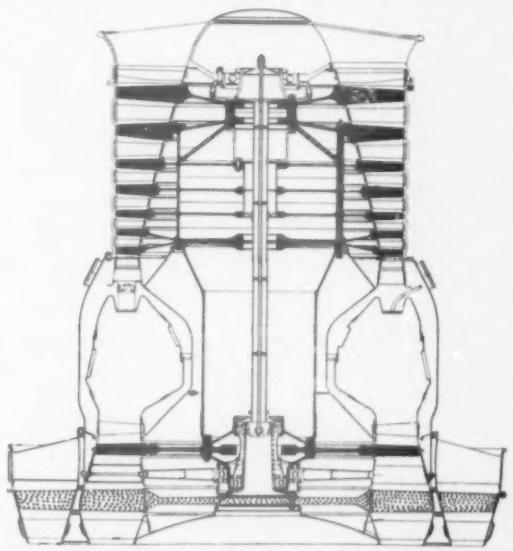


Fig. 3. This specialized ducted-fan engine is designed to provide lift thrust for VTOL performance; engines similar to this would be mounted in the fuselage of the transport on page 194.

In this application the lift/thrust engines are of the ducted-fan type primarily in order to provide the lowest cruising fuel consumption combined with the ability to provide vertical thrust during take-off (see Fig. 2). Their high thrust/weight ratio is also advantageous.

The engines which are shut down during cruising flight and only used for take-off and landing must have the minimum weight. By the use of ducted-fan engines, a thrust/weight ratio of about 14 : 1 can be achieved in this specialized form of engine, giving a weight of approximately 750 lb. for an engine of 10,000-lb. lift. These engines are of rear fan configuration, as shown in Fig. 3. The ducted-fan configuration has the further advantages that, for a given thrust, the engine is shorter than a straight turbojet, and has a lower fuel consumption.

Another important advantage of the lower jet velocity inherent in the ducted fan compared with the turbojet is the reduced noise level. This is a factor which will be of considerable importance for vertical take-off airliners.

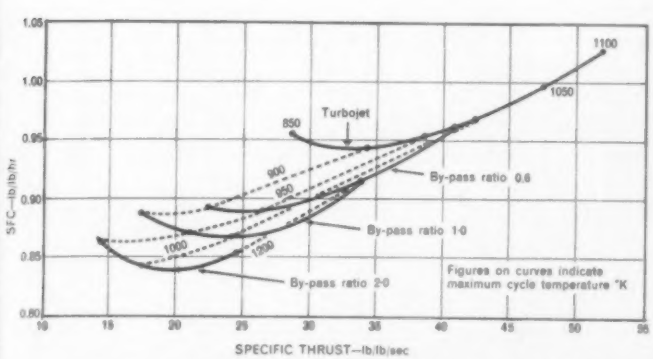


Fig. 2. A low cruising fuel consumption is essential for transport aircraft; these curves show how the ducted-fan engine with a high by-pass ratio has an s.f.c. 10% lower than the pure turbojet. The curves apply to a cruising speed of 500 knots at 36,000 ft.

Powerplant Survey—3 . . . .

Types of VTOL Engines Compared

A recent lecture by MR. H. PEARSON, B.A., F.R.AE.S., M.I.MECH.E., *chief research engineer of Rolls-Royce, indicated his company's current thoughts on powerplants for VTOL aircraft*

CONSIDERATION of VTOL aircraft by the Rolls-Royce team has been based mainly on "flat-risers" rather than "tail-sitters." A compromise solution has, however, also been studied in which the aircraft takes-off vertically in a nose-up attitude and lands in a horizontal attitude; this arrangement has advantages where propulsive thrust is high.

Safety is considered essential for VTOL aircraft; if a lift engine fails, the aircraft and crew must not be endangered more than in conventional aircraft designed for a similar rôle. This leads to the need for multiple lift engines. A second requirement is that lift engines should weigh as little as possible.

Early studies suggested that high thrust/weight ratios would be possible with small engines designed for lift purposes only. Both safety and low weight requirements could be met with banks of simple lightweight lift engines.

When Rolls-Royce VTOL studies began they were concentrated mainly on long-range supersonic aircraft in which jet-lift VTOL was associated with a narrow-delta configuration. In this case propulsive thrust is only 20-30% of aircraft weight. At take-off and landing, all of the aircraft's weight is supported by lift engines.

Recently Rolls-Royce has also considered VTOL subsonic civil aircraft. For these, noise and ground erosion might appear to militate against direct jet-lift engines; as a result the company has studied fan-lift engines.

Jet-lift studies began in 1949 with the development of the RB.82, a lightweight missile engine which eventually gave 1,670 lb. thrust. This engine first ran in January, 1951; it weighed 240 lb. and had a specific weight of 0.16. A direct development of this engine was the RB.93 Soar, which first ran in 1953. This gave a 2,000-lb. thrust at 272 lb. weight, which represents a specific weight of 0.136.

Studies at this time suggested that specific weight could be reduced to 0.1 or less. To study experimentally the feasibility of a VTOL system the famous Flying Bedstead was then designed, with two 5,000-lb. s.t. Nene engines. Tests with this showed that rapid engine response to the throttle and accurate engine-thrust control were essential.

Based on Flying Bedstead tests it was decided to design a special jet-lift engine. In addition to the safety and good specific weight which can be achieved with small engines, their throttle response rate is better and vertical installation in fuselages dictates small engines. As a result of these considerations the RB.108 was evolved; it gives 2,150 lb. thrust (including control-bleed thrust) for a weight of 242 lb. Four of these lift engines and one propulsion engine are installed in the Short S.C.1.

Modern knowledge of compressor and combustion-chamber performance coupled with new constructional techniques and materials, particularly plastics, suggest that in future specific weights as low as 0.06 can be achieved, compared with 0.112 for the RB.108. In this case the weight of lift engines will compare with undercarriage weights. It is expected that the 0.06 specific weight can be maintained up to a thrust of about 5,000 lb.

At first sight, simple jet-lift engines appeared unsuitable for civil VTOL aircraft because they would be too noisy, their fuel consumption might be too great, ground erosion might be excessive and augmented engines might prove lighter. As a result Rolls-Royce considered other powerplants.

Noise was a major consideration; to reduce levels to those initially requested, jet velocities as low as 500-600 ft./sec. were needed compared with the 2,000 ft./sec. of jet-lift engines. This demanded fans and much study was devoted to their installation and to engines to drive them.

Many applications are possible. Basically, the exhaust of a jet engine is used to drive a turbine which in turn drives an air propulsion system. The turbine and propulsive fan may be integral with the engine, or the fan may be distant from it. In this case the exhaust may be ducted to a turbine-driven fan, or the turbine may drive a compressor supplying air to a turbofan. All these systems have been studied.

One example was a rear turbofan version of the RB.108 with the outlet velocity from the fan and exhaust limited to 580 ft./sec. Overall weight was about 780 lb. and lift thrust, assuming that the air bled from the engine drove control fans, was about 6,220 lb. Although this powerplant was heavier than a simple jet lift engine, fuel consumption was lower and the weight for engine-plus-fuel was rather less than with a simple jet engine for a three-minute running time.

This led to a study of turbofans with other augmentation ratios (i.e., other outlet velocities). It showed that there was little justification for turbofans on a weight basis, but they had a better engine-plus-fuel weight; a minimum seemed to exist at an outlet velocity of about 600 ft./sec.

The weights given apply only to the bare engine and fan; total installed weight depends on the aircraft application. Studies show that fans have little if any installed weight advantage over simple jet-lift engines. And as new jet-lift engines can be designed at a much lower weight, it is probable that large weight penalties will follow if fans are added.

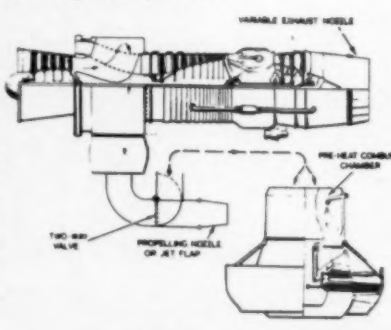
It must also be remembered that there are limits on the reduction of jet velocity that can be provided by turbofans. Lowering the velocity means that a low thrust is produced per unit area of fan. This leads to increases in fan area and thus higher installed weights and aircraft all-up weights.

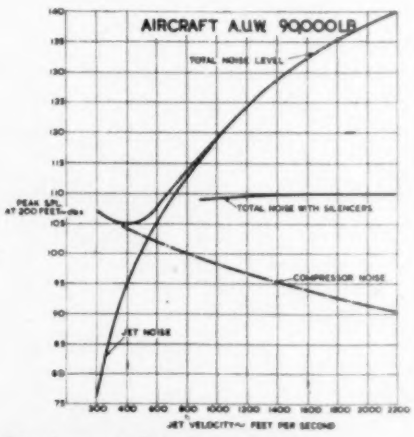
Low-velocity fans seem to be limited to low-speed aircraft. For high subsonic speed, higher velocity fans will be needed and these will not meet suggested noise limits. For supersonic aircraft simple jet-lift engines will almost certainly be needed.

The main aim of a low jet velocity with fans is to reduce noise. But with a fan velocity as low as 580 ft./sec. the noise level for a 90,000-lb. aircraft will be 105 db. The compressor noise is then almost as great as jet noise. In fact, because of compressor noise there is no point in reducing fan velocity below about 600 ft./sec. and noise levels below 104 db. cannot be obtained.

With jet-lift engines it is easier to reduce their higher initial noise level. With grouping and the use of silencers their noise level for a 90,000-lb. aircraft is about 110 db.

Although lifting fans are still being studied by Rolls-Royce, it seems probable that simple jet-lift engines will be equally good, simpler to install and will probably weigh less.





Above is a Rolls-Royce scheme for a propulsion by-pass turbojet integrated with a fan-lift unit. The graph (right) shows how the noise level of fan and turbojet lift engines varies with jet velocity.

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The Royal Air Force standard
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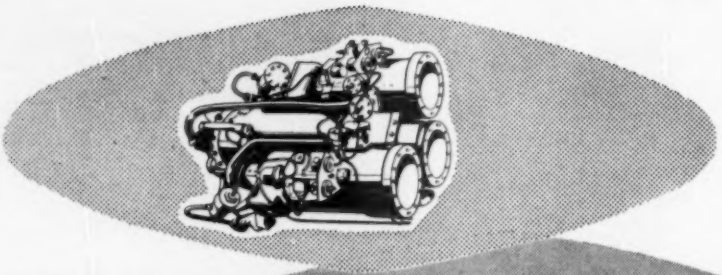
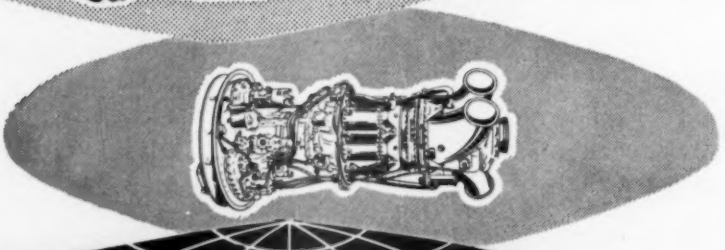


TRIPLE SCORPION an aircraft rocket engine which provides a source of extra power at all altitudes. Designed for sustained firing and long operational life.

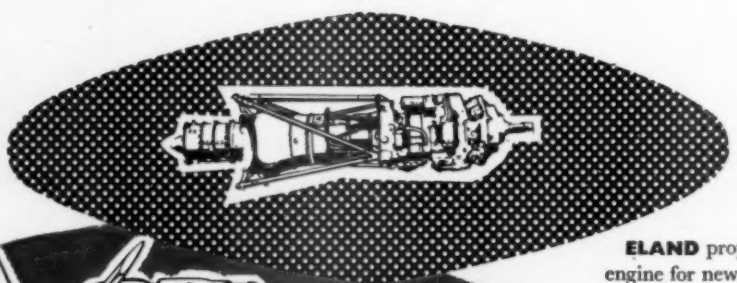
GAZELLE free turbine engine (1650 s.h.p.) powers the Westland Wessex and the Bristol 192. Now chosen to power the twin-engined Wiltshire.

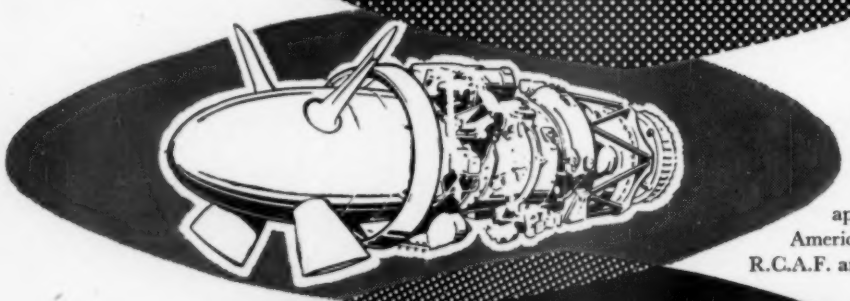


NAPIER AERO ENGINES

for the world

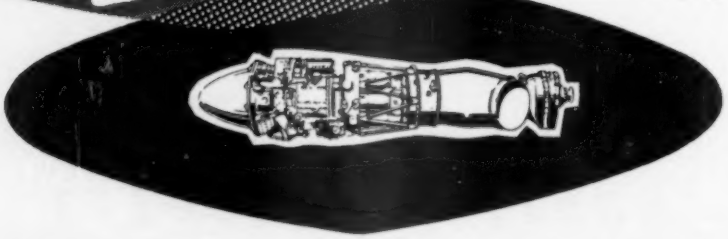
ELAND engines designed for the Fairey Rotodyne are basically the standard Eland with an auxiliary compressor mounted at the rear.





ELAND propeller-turbine engine for new airliners and for the conversion of piston engined airliners. The Eland which powers the Canadair 540 and Convair 540, is rated at 3,500 e.h.p. and is approved by British A.R.B. and American F.A.A. In service with the R.C.A.F. and Allegheny Airlines U.S.A.

ELAND engines for the Westminster are installed horizontally on top of the fuselage with a mechanical drive to the rotor shaft.



D. NAPIER & SON LIMITED, LONDON, W3 *MEMBER OF THE ENGLISH ELECTRIC AVIATION GROUP*

International Powerplant Data

TURBINE ENGINES

Engines		Compressor				No. of combustion chambers	No. of turbine stages	Sea level static performance									Overall dimensions			Dry weight	Power/weight ratio
Make and name	Type	Type	Stages	Pressure ratio	Air mass flow			Take-off					Maximum continuous				Length of engine	Length with ex. cone	Width or height		
								lb. th.	s.h.p.	e.h.p.	r.p.m.	lb./*/hr.	lb. th.	s.h.p.	r.p.m.	lb./*/hr.	in.	in.	in.	lb.	*/lb.wt.
CANADA					lb./sec.																
Canadian Pratt & Whitney Aircraft Co.																					
PT-6A3 (also S.T.)	Tp.	Ax.+C	3+1	6 : 1	N.A.	Ann.	1×1	N.A.	N.A.	500	N.A.	0.69	N.A.	450c	N.A.	0.71	N.A.	66.0	19.0	250	2.0
Orenda Engines																					
Orenda Series 14	Tj.	Ax.	10	6.1 : 1	130.0	6	2	7,500	—	—	7,800	0.997	6,600	—	7,600	N.A.	N.A.	143.6	42.0	2,470	3.04
FRANCE																					
Marcel Dassault																					
R.7 Farandole	Tj.	Ax.	7	3.8 : 1	55.0	Ann.	1	3,110	—	—	11,800	1.08	2,760	—	11,200	1.04	N.A.	94.5	28.75	750	4.15
Hispano Suiza																					
Verdon 350 (Rolls-Royce licence)	Tj.	C.	1	4.9 : 1	132.0	9	1	7,716	—	—	11,100	1.10	6,834	—	10,800	N.A.	N.A.	104.0	50.0	2,072	3.72
Snecma																					
Atar 8	Tj.	Ax.	9	5.2 : 1	150.0	Ann.	2	9,700	—	—	8,400	0.98	7,385	—	8,150	0.935	112.0	181.0	40.0	2,312	4.19
Atar 9C	Tj.	Ax.	9	5.2 : 1	150.0	Ann.	2	14,080*a*	—	—	8,650	2.075*a*	N.A.	—	N.A.	N.A.	N.A.	266.0	42.0	2,755	5.11*a*
Turbomeca																					
Palas 1	Tj.	C.	1	3.95 : 1	7.05	Ann.	1	352	—	—	34,000	1.17	287	—	N.A.	1.13	35.1	47.25	16.0	158	2.22
Marboré II	Tj.	C.	1	3.85 : 1	17.64	Ann.	1	880	—	—	22,600	1.08	710	—	21,000	1.09	44.3	61.6	25.0	314	2.80
Marboré VI	Tj.	C.	1	3.84 : 1	N.A.	Ann.	1	1,058	—	—	21,500	1.08	1,058	—	N.A.	1.08	N.A.	56.0	22.0	322	3.29
Gourdon	Tj.	C.	1	5.00 : 1	N.A.	Ann.	1	1,410	—	—	21,500	0.99	1,270	—	N.A.	0.99	N.A.	69.0	22.0	375	3.76
Astazou	Tp.	Ax.+C.	2	5.81 : 1	N.A.	Ann.	3	66	469	495	43,000	0.62	83	408	43,000	0.63	N.A.	57.0	18.0	320	1.47
Bastan	Tp.	Ax.+C.	2	5.45 : 1	N.A.	Ann.	2×1	145	800	855	33,500	0.65	143	650	33,500	0.68	60.9	N.A.	22.0	607	1.32
Artouste II	S.T.	C.	1	3.88 : 1	6.60	Ann.	2	77	400	430	34,000	1.07	66	330	34,000	1.10	57.0	N.A.	23.0	360	1.11
Artouste III	S.T.	C.	1	5.20 : 1	N.A.	Ann.	3	N.A.	550	N.A.	34,000	0.65	N.A.	550	34,000	0.65	58.0	N.A.	21.0	410	1.34
Turmo IIIB	S.T.	Ax.+C.	2	5.65 : 1	N.A.	Ann.	2×1	N.A.	812	N.A.	34,050	0.67	N.A.	640	34,050	0.68	65.0	N.A.	31.0	560	1.45
Turmo IIIC	S.T.	Ax.+C.	2	5.50 : 1	N.A.	Ann.	2×1	N.A.	1,100	N.A.	33,000	0.68	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Palouste IV	G.G.	C.	1	3.80 : 1	2.71	Ann.	2	—	—	252*g*	34,000	1.23	—	231*g*	N.A.	N.A.	41.8	47.0	22.0	198	1.27
GERMAN DEMOCRATIC REPUBLIC																					
Type 014	Tj.	Ax.	12	N.A.	110.0	Ann.	2	6,945	—	—	N.A.	0.85	N.A.	—	N.A.	N.A.	N.A.	161.4	38.6	2,200	3.16
ITALY																					
Fiat																					
Type 4002	Tj.	C.	1	4.0 : 1	13.9	Ann. Rev.	1	716	—	—	25,000	1.21	650	—	24,400	1.18	N.A.	34.8	22.5	194	3.68
Type 4032	Tj.	Ax.	9	5.5 : 1	110.0	Cann. 10	1	5,950	—	—	8,200	N.A.	N.A.	—	N.A.	N.A.	N.A.	100.78	42.12	1,080	5.51
Type 4700	G.G.	C.	1	4.0 : 1	10.4	Ann.	1×1	—	—	542*g*	25,000	0.55	—	483*g*	24,400	0.57	48.4	51.18	25.91	304	1.79
JAPAN																					
Nippon Jet-Engine Co.																					
Model J3–1	Tj.	Ax.	8	4.57 : 1	51.8	Ann.	1	2,646	—	—	N.A.	N.A.	N.A.	—	N.A.	1.08	N.A.	72.85	28.35	815	3.25
UNITED KINGDOM																					
Blackburn																					
Turmo 603	S.T.	C.	1	3.86 : 1	7.26	Ann.	1×1	N.A.	425	N.A.	34,000	1.105	N.A.	375	33,000	1.13	47.9	N.A.	26.4	370	1.15
Artouste 600	S.T.	C.	1	4.00 : 1	7.27	Ann.	2	N.A.	472	N.A.	35,000	0.98	N.A.	414	34,000	1.03	N.A.	54.0	17.5	295	1.60
A 129	S.T.	Ax.+C.	2+1	6.50 : 1	11.0	Ann.	2×1	N.A.	968	N.A.	35,000	0.681	N.A.	815	34,000	0.718	60.0	N.A.	20.0	390	2.15
Palouste 505	G.G.	C.	1	3.81 : 1	7.70	Ann.	2	N.A.	—	N.A.	35,000	1.26	—	N.A.	N.A.	N.A.	33.4	N.A.	17.5	214	N.A.
Bristol Siddeley Engines																					
Viper Mk. 102 A.S.V.8	Tj.	Ax.	7	4.1 : 1	32.0	Ann.	1	1,750	—	—	13,800	1.07	1,480	—	13,100	1.075	46.58	66.98	24.3	490	3.57
Viper A.S.V.11	Tj.	Ax.	7	3.9 : 1	45.0	Ann.	1	2,500	—	—	13,800	1.04	2,170	—	13,100	1.01	N.A.	64.097	24.55	500	5.0
Viper A.S.V.12	Tj.	Ax.	7	N.A.	45.0	Ann.	1	2,700	—	—	13,800	1.08	N.A.	—	N.A.	N.A.	N.A.	63.997	24.55	549	4.92
Viper A.S.V.20	Tj.	Ax.	N.A.	N.A.	55.0	Ann.	N.A.	3,240	—	—	14,400	1.01	N.A.	—	N.A.	N.A.	N.A.	66.67	24.5	575	5.63
P.209	Tj.	Ax.	N.A.	N.A.	55.0	Ann.	N.A.	3,000–3,830	—	—	14,400	0.845–0.975	N.A.	—	N.A.	N.A.	N.A.	68.50	24.5	593	5.06–6.46
Orpheus 701 B.Or.2	Tj.	Ax.	7	N.A.	N.A.	Cann. 7	1	4,700	—	—	N.A.	1.057	4,130	—	N.A.	1.042	N.A.	73.0	32.4	795	5.91
Orpheus 803 B.Or.3	Tj.	Ax.	7	N.A.	N.A.	Cann. 7	1	5,000	—	—	N.A.	1.08	4,200	—	N.A.	1.05	N.A.	75.45	32.4	835	5.99
Orpheus 100 B.Or.4	Tj.	Ax.	7	N.A.	N.A.	Cann. 7	1	4,230	—	—	N.A.	0.96	3,600	—	N.A.	0.943	N.A.	77.52	32.4	900	4.70
Orpheus B.Or.12	Tj.	Ax.	8	N.A.	N.A.	N.A.	N.A.	6,810	—	—	N.A.	0.967	5,825	—	N.A.	0.933	N.A.	81.40	32.4	1,110	6.14
Sapphire A.S.Sa.7R	Tj.	Ax.	13	N.A.	N.A.	Ann.	2	12,230*a*	—	—	8,600	1.20*a*	9,600	—	8,200	0.845	N.A.	107.70	37.4	3,180*a*	3.84*a*
Olympus 104 B.Ol.12	Tj.	Ax.×Ax.	7×8	N.A.	N.A.	Cann. 10	1×1	13,000	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	132.0	42.4	N.A.	N.A.
Olympus 201 B.Ol.7	Tj.	Ax.×Ax.	5×7	N.A.	N.A.	Cann. 8	1×1	17,000	—	—	N.A.	*0.80*	N.A.	—	N.A.	N.A.	N.A.	126.4	42.0	*3,600*	4.72
BE58	Tf.	Ax. (fan) ×Ax.	2×7	N.A.	N.A.	Ann.	1×2	14,500	—	—	N.A.	0.572	N.A.	—	N.A.	N.A.	123.0	N.A.	48.0	2,600	5.6
Double Mamba A.S.M.D.8	Tp.	Ax.	11	5.85 : 1	2×21.0	Ann.	3	710	3,600	3,875	15,000	0.66	710	3,875*c*	15,000	0.66	84.62	103.35	56.55	2,500	1.55
Proteus 765	Tp.	Ax.+C.	12+1	7.2 : 1	44.3	8	2×2	1,260	3,915	4,400	11,593	0.593	1,155	3,485	11,500	0.607	N.A.	100.6	40.1	2,900	1.52
Proteus 770	Tp.	Ax.+C.	12+1	7.2 : 1	N.A.	8	2×2	1,260	4,130	4,615	11,775	0.565	1,155	3,680	11,500	0.578	N.A.	100.6	40.1	2,900	1.59

Note.—Data in italics are estimated or unofficial. Abbreviations.—Ann., annular; Ax., axial; B.P., by-pass engine; C., centrifugal; Cann., cannular; G.G., gas generator; N.A., not available; S.T., shaft-turbine engine; Tf., turbofan; Tj., turbojet; Tp., turboprop; * lb. thrust, s.h.p., e.h.p. or g.h.p. as applicable to respective type of engine; *a*, with afterburner; *b*, less tailpipe; *c*, e.h.p.; *d*, compressor r.p.m.; *e*, power turbine r.p.m.; *f*, with reduction gear; *g*, gas h.p.; *h*, with reverser and sound suppressor; *w*, with water injection.

Turbine Engines . . . .

Engine		Compressor				No. of combustion chambers	No. of turbine stages	Sea level static performance									Overall dimensions			Dry weight	Power/weight ratio
								Take-off					Maximum continuous								
Make and name	Type	Type	Stages	Pressure ratio	Air mass flow			lb. th.	s.h.p.	e.h.p.	r.p.m.	lb./*/hr.	lb. th.	s.h.p.	r.p.m.	lb./*/hr.	Length of engine	Length with ex. cone	Width or height	lb.	*/lb.wt.
					lb./sec.												in.	in.	in.	lb.	
UNITED KINGDOM—Cont.																					
de Havilland Engine Co.																					
Gyron Junior D.G.J.10	Tj.	Ax.	8	N.A.	N.A.	Ann.	N.A.	10,000	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	70.0	N.A.	32.3	N.A.	N.A.
Gnome H.1000	S.T.	Ax.	10	8.3 : 1	12.4	Ann.	2×1	—	1,000	—	19,500*e*	0.65	—	900	19,500*e*	0.67	54.8	N.A.	18.2	350*f*	2.86
Gnome H.1200	S.T.	Ax.	10	8.3 : 1	12.5	Ann.	2×1	—	1,250	—	19,500*e*	0.63	—	1,050	19,500*e*	0.64	54.8	N.A.	18.2	435*f*	2.87
Gnome P.1200	Tp.	Ax.	10	8.3 : 1	12.5	Ann.	2×1	—	1,150	—	20,000*e*	0.65	—	1,000	19,000*e*	0.68	79.3	N.A.	17.0	630	1.83
D. Napier and Son																					
Eland 504	Tp.	Ax.	10	7.0 : 1	33.5	6	3	700	3,230	3,500	12,500	0.61	625	2,670	12,000	0.63	95.5	116.0	36.0	1,820	1.92
Eland E.211	S.T.	Ax.	10	7.0 : 1	33.5	6	3	550	3,500	3,710	12,500	0.60	520	2,850	12,500	0.63	135.0	N.A.	36.0	1,418	2.61
Gazelle N.Ga.2 (revised)	S.T.	Ax.	11	6.25 : 1	16.8	6	2×1	260	1,650	1,750	20,000	0.64	230	1,450	19,400	0.65	70.0	N.A.	33.5	830	2.11
Gazelle N.Ga.13	S.T.	Ax.	11	5.9 : 1	16.1	6	2×1	230	1,450	1,540	19,400	0.65	190	1,200	18,600	0.67	70.0	N.A.	33.5	830	1.86
Rolls-Royce																					
Avon R.A.24	Tj.	Ax.	N.A.	N.A.	N.A.	Cann. 8	N.A.	11,250	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	126.0	41.5	N.A.	N.A.
Avon R.A.29	Tj.	Ax.	16	9.27 : 1	173.0	Cann. 8	3	10,500	—	—	8,000	0.775	8,875	—	7,560	0.73	N.A.	124.8	41.5	3,341	3.14
Avon R.A.29/3	Tj.	Ax.	16	9.63 : 1	173.0	Cann. 8	3	11,700	—	—	8,000	0.805	9,810	—	7,800	0.749	N.A.	126.0	41.5	3,446	3.39
Avon R.A.29/6	Tj.	Ax.	17	N.A.	N.A.	Cann. 8	3	12,500	—	—	8,050	0.762	10,520	—	7,700	0.712	N.A.	134.0	41.5	3,491	3.58
Avon R.B.146	Tj.	Ax.	N.A.	N.A.	N.A.	Cann. 8	N.A.	13,220	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	145.0	41.5	N.A.	N.A.
Conway R.Co.11	B.P.	Ax.×Ax.	N.A.	N.A.	N.A.	Cann. 10	N.A.	17,250	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	136.0	42.0	N.A.	N.A.
Conway R.Co.12	B.P.	Ax.×Ax.	7×9	14.0 : 1	282.0	Cann. 10	1×2	17,500	—	—	9,980	0.725	14,625	—	9,390	0.69	N.A.	131.0	42.0	4,504	3.89
Conway R.Co.15	B.P.	Ax.×Ax.	7×9	14.0 : 1	295.0	Cann. 10	1×2	18,500	—	—	9,895	0.701	15,000	—	9,500	0.667	N.A.	131.0	42.0	4,544	4.07
Conway R.Co.42	B.P.	Ax.×Ax.	N.A.	N.A.	363.0	Cann. 10	N.A.	20,250	—	—	9,955	0.622	16,500	—	9,575	0.592	N.A.	N.A.	N.A.	5,001	4.05
R.B.108	Tj.	Ax.	N.A.	N.A.	N.A.	Ann.	N.A.	2,010	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	42.0	20.8	N.A.	N.A.
R.B.141	B.P.	Ax.×Ax.	N.A.	N.A.	N.A.	Cann. 10	N.A.	15,000	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	114.5	39.4	N.A.	N.A.
R.B.145	Tj.	Ax.	N.A.	N.A.	N.A.	Ann.	N.A.	2,750	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	63.7	20.8	N.A.	N.A.
R.B.163	B.P.	Ax.×Ax.	N.A.	N.A.	N.A.	Cann. 10	N.A.	10,100	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Dart R.Da. 3 Mk. 506	Tp.	C.	2	5.5 : 1	20.0	7	2	365	1,400	1,540	14,500	0.727	295	1,120	13,800	0.865	95.0	N.A.	37.9	1,044	1.47
Dart R.Da. 6 Mk. 510	Tp.	C.	2	5.5 : 1	20.0	7	2	370	1,600	1,740	14,500	0.69	320	1,365	14,000	0.79	97.6	N.A.	37.9	1,152	1.57
Dart R.Da.7/2 Mk. 526, 527, 528 and 529 and R.Da. 7/3 Mk. 530	Tp.	C.	2	5.8 : 1	22.0	7	3	505	1,910	2,105	15,000	0.66	505	1,910	15,000	0.735	97.6	N.A.	37.9	1,250	1.72
Dart R.Da.10 Mk. 540	Tp.	C.	2	6.25 : 1	25.5	7	3	670	2,440†	2,660	15,000	0.64	585	2,100	14,500	0.732	98.5	N.A.	37.9	1,323	2.01
Dart R.Da.11 Mk. 541	Tp.	C.	2	6.25 : 1	25.5	7	3	655	2,100	2,350	15,000	0.675	570	1,820	14,500	0.785	98.5	N.A.	37.9	1,323	1.77
Tyne R.Ty.1 Mk. 506	Tp.	Ax.×Ax.	6×9	13.0 : 1	46.0	Cann. 10	1×3	1,260	4,500	4,985	15,250	0.539	970	3,995	13,500	0.530	100.25	N.A.	40.5	2,023	2.46
Tyne R.Ty.11 Mk. 512	Tp.	Ax.×Ax.	6×9	13.0 : 1	46.0	Cann. 10	1×3	1,290	5,030	5,545	15,250	0.509	1,080	4,445	14,100	0.510	100.25	N.A.	40.5	2,220	2.50
Tyne R.Ty.12 Mk. 515	Tp.	Ax.×Ax.	6×9	13.0 : 1	46.0	Cann. 10	1×3	1,120	5,300	5,730	15,250	0.485	920	4,630	14,100	0.495	100.25	N.A.	40.5	2,120	2.70
U.S.A.																					
AiResearch Manufacturing Company																					
G.T.C.85–35	G.G.	C.	2	N.A.	5–6	Cann. 1	1	—	—	85*g*	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	35.5–39	N.A.	25.7–27	207–230	N.A.
Allison																					
J33–A–41	Tj.	C.	1	4.25 : 1	87.0	14	1	4,600	—	—	11,750	1.14	4,600	—	11,750	1.12	N.A.	159.5	49.4	1,790	2.57
J71–A–2	Tj.	Ax.	16	8.3 : 1	*160.0*	Cann. 10	3	10,200	—	—	6,100	0.80	N.A.	—	N.A.	N.A.	N.A.	191.0	47.6	4,090	2.49
T63	Tp.	Ax.+C.	7+1	6.2 : 1	3.0	1	2×1	N.A.	250	N.A.	N.A.	0.70	N.A.	212	N.A.	0.73	38.5	N.A.	19.5	106	2.36
T56–A–1	Tp.	Ax.	14	9.25 : 1	32.5	Cann. 6	4	726	3,460	3,750	13,820	0.54	N.A.	3,375*c*	13,820	0.46	N.A.	145.1	40.0	1,645	2.28
T56–A–7	Tp.	Ax.	14	9.25 : 1	39.0	Cann. 6	4	N.A.	N.A.	4,050	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	145.2	36.0	N.A.	N.A.
Model 501–D13	Tp.	Ax.	14	9.25 : 1	32.5	Cann. 6	4	726	3,460	3,750	13,820	0.54	702	3,094	13,820	0.552	N.A.	145.2	36.0	1,750	2.14
Boeing																					
Model 502–10F	Tp.	C.	1	N.A.	4.24	2	1×1	N.A.	320	N.A.	3,400	0.92	—	N.A.	N.A.	N.A.	N.A.	41.5	24.25	300	1.07
T60–2	Tp.	C.	1	-4.4 : 1	5.5	2 Rev.	1×1	N.A.	400	N.A.	6,200	0.72	—	350	6,000	0.76	—	60.0	23.62	325	1.23
Continental																					
J69–T–19B (Turboméca Marboré)	Tj.	C.	1	4.0 : 1	16.7	Ann.	1	1,060	—	—	21,250	1.27	860	—	20,000	1.25	44.3	61.53	22.32	317	3.34
Model 356–9 (J69 series)	Tj.	Ax.+C.	1+1	N.A.	N.A.	Ann.	1	1,400	—	—	21,000	1.04	1,200	—	20,300	1.05	N.A.	N.A.	N.A.	N.A.	N.A.
Fairchild																					
J44–R–26	Tj.	C./Ax.	1	3.25 : 1	N.A.	Ann.	1	1,100	—	—	N.A.	1.30	N.A.	—	N.A.	N.A.	N.A.	92.0	22.3	365*b*	3.02
General Electric																					
CF700–1	Tf.	Ax.	8	N.A.	N.A.	Ann.	2+1 (Tf.)	4,000	—	—	N.A.	0.69	3,770	—	N.A.	0.69	N.A.	70.0	33.0	585	6.84
J47–GE–33	Tj.	Ax.	12	5.5 : 1	103.0	8	1	7,650*a*	—	—	7,950	2.00*a*	5,100	—	7,950	1.13	N.A.	228.0	36.75	3,196	2.40*a*
J79–GE–3A	Tj.	Ax.	17	12.0 : 1	167.9	Cann. 10	3	16,000*a*	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	204.0*a*	32.5	3,190	5.02*a*
CJ–805–3	Tj.	Ax.	17	13.0 : 1	167.9	Cann. 10	3	11,200	—	—	7,684	0.806	9,500	—	N.A.	0.738	109.56	188.9*h*	31.6	3,190*h*	3.51
CJ–805–23 (TF35)	Tf.	Ax.	17	13.0 : 1	167.9	Cann. 10	3+Tf.	16,100	—	—	7,684	N.A.	N.A.	—	N.A.	N.A.	N.A.	144.0	53.0	3,825	4.21
J85–GE–5	Tj.	Ax.	8	N.A.	N.A.	Ann.	2	3,850*a*	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	32.5	104.0	*31.0*	525	7.33*a*
J85–GE–7	Tj.	Ax.	8	N.A.	N.A.	Ann.	2	2,450	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	39.3	42.0	31.5	325	7.54
J93–GE–3	Tj.	Ax.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
T58–GE–6 (CT58–100)	S.T.	Ax.	10	8.3 : 1	12.4	Ann.	2×1	N.A.	1,050	N.A.	19,500*e*	0.64	N.A.	900	N.A.	N.A.	55.0	N.A.	27.3	280	3.75

Note.—Data in italics are estimated or unofficial. Abbreviations.—Ann., annular; Ax., axial; B.P., by-pass engine; C., centrifugal; Cann., cannular; G.G., gas generator; N.A., not available; S.T., shaft-turbine engine; Tf., turbofan; Tj., turbojet; Tp., turboprop; * lb. thrust, s.h.p., e.h.p. or g.h.p. as applicable to respective type of engine; † 3,200 mil. type test; *a*, with afterburner; *b*, less tailpipe; *c*, e.h.p.; *d*, compressor r.p.m.; *e*, power turbine r.p.m.; *f*, with reduction gear; *g*, gas h.p.; *h*, with reverser and sound suppressor; *w*, with water injection.

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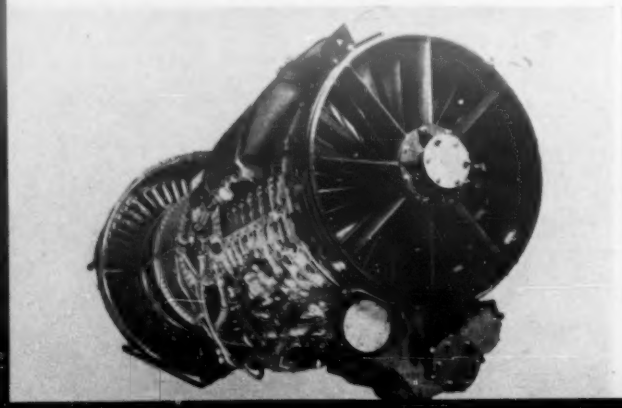
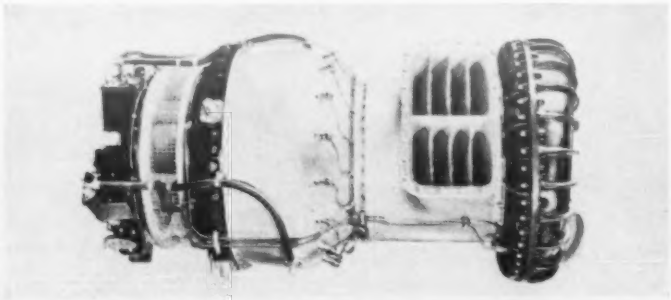
Turbine Engines . . . .

Engine: Make and name	Type	Compressor: Type	Stages	Pressure ratio	Air mass flow	No. of combustion chambers	No. of turbine stages	Sea level static performance: Take-off: lb. th.	s.h.p.	e.h.p.	r.p.m.	lb./*/hr.	Maximum continuous: lb. th.	s.h.p.	r.p.m.	lb./*/hr.	Overall dimensions: Length of engine	Length with ex. cone	Width or height	Dry weight	Power/weight ratio
					lb./sec.			lb. th.	s.h.p.	e.h.p.	r.p.m.	lb./*/hr.	lb. th.	s.h.p.	r.p.m.	lb./*/hr.	in.	in.	in.	lb.	*/lb.wt.
U.S.A.—Cont.																					
General Electric (cont.)																					
T58–GE–8	S.T.	Ax.	N.A.	N.A.	N.A.	Ann.	N.A.	N.A.	1,350	N.A.	N.A.	0.574	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4.5
T64–GE–2 (T64–GE–4:Tp.)	S.T.	Ax.	14	N.A.	N.A.	Ann.	2×1	N.A.	2,570	N.A.	5,200	0.506	N.A.	N.A.	N.A.	N.A.	N.A.	91.0	N.A.	854	3.01
Lycoming																					
T53–L–5 (T53–L–3:Tp.)	S.T.	Ax.+C.	5+1	6.0 : 1	10.7	Ann. Rev.	1×1	113	960	1,005	25,240	0.664	N.A.	N.A.	N.A.	N.A.	48.0	N.A.	23.0	470*b*	2.14
YT55–L–1A (T55–L–3:S.T.)	Tp.	Ax.+C.	7+1	N.A.	N.A.	Ann. Rev.	1×2	N.A.	1,850	1,934	18,660	0.648	N.A.	N.A.	N.A.	N.A.	58.85	N.A.	24.25	695*b*	2.78
Pratt & Whitney																					
J60–P–3 (JT12A–5)	Tj.	Ax.	9	6.5 : 1	N.A.	Cann. 8	2	3,000	—	—	N.A.	0.96	N.A.	—	N.A.	N.A.	N.A.	76.0	21.90	436	6.88
J60 (JT12A–21)	Tj.	Ax.	9	6.5 : 1	N.A.	Cann. 8	2	4,025*a*	—	—	N.A.	2.42	N.A.	—	N.A.	N.A.	N.A.	126.0	21.90	651	6.18*a*
JTF10A–1	Tf.	Ax.	N.A.	N.A.	N.A.	N.A.	N.A.	8,250	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	2,100	3.93
J52–P–4 (JT8)	Tj.	Ax.×Ax.	N.A.	N.A.	N.A.	Cann. 8	N.A.	7,250	—	—	N.A.	0.80	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
J57–P–16 (JT3C–21)	Tj.	Ax.×Ax.	9×7	13.0 : 1	200.0	Cann. 8	1×2	16,900*a*	—	—	8,200	2.30	N.A.	—	N.A.	N.A.	N.A.	267.2	39.6	4,750	3.56*a*
JT3C–6	Tj.	Ax.×Ax.	9×7	13.0 : 1	200.0	Cann. 8	1×2	13,500*w*	—	—	8,200	0.775	9,500	—	N.A.	0.765	N.A.	167.5	38.88	4,234	3.19*w*
TF33–P–3 (JT3D–2)	Tf.	Tf.× Ax.×Ax.	2× 6×7	13.0 : 1	430.0	Cann. 8	1×3	17,000	—	—	8,200	0.52	N.A.	—	N.A.	N.A.	148.0	180.0	53.0	3,900	4.36
J75–P–3 and P–17	Tj.	Ax.×Ax.	8×7	12.0 : 1	*260.0*	Cann. 8	1×2	24,500*a*	—	—	8,000	2.15	N.A.	—	N.A.	N.A.	N.A.	237.6	43.0	5,875	4.17*a*
JT4A–9	Tj.	Ax.×Ax.	8×7	12.0 : 1	260.0	Cann. 8	1×2	16,800	—	—	8,000	0.81	13,500	—	N.A.	0.75	N.A.	144.1	43.0	5,050	3.33
JT4D–2	Tf.	Tf.× Ax.×Ax.	2×6×7	N.A.	N.A.	Cann. 8	1×3	25,000	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	146.0	N.A.	62.5	6,200	4.03
T58 (JT11)	Tj.	Ax.	9	N.A.	N.A.	Ann.	2	*30,000*†	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	*50.0*	N.A.	N.A.
T34–P–3 and 7W	Tp.	Ax.	13	6.7 : 1	67.0	Ann.	3	1,250	5,500	6,000	11,000	0.63	1,125	4,750	5,200	0.655	N.A.	156.8	33.75	2,670	2.25
T34–P–9W (PT2G–6)	Tp.	Ax.	13	6.7 : 1	67.0	Ann.	3	—	5,950	7,500	N.A.	0.55	N.A.	—	N.A.	N.A.	N.A.	155.1	34.06	2,870	2.61
Solar																					
YT62 Titan (and YT 66)	S.T.	C.	1	3.3 : 1	1.4	Ann.	1	12	55	N.A.	56,700	1.30	N.A.	N.A.	N.A.	N.A.	N.A.	24.75	12.5	50	1.12
T–150	S.T.	C.	1	N.A.	N.A.	1	1	N.A.	190	N.A.	34,750	N.A.	N.A.	170	N.A.	N.A.	N.A.	33.0	25.0	170	1.12
Westinghouse																					
J34–WE–46	Tj.	Ax.	11	4.35 : 1	N.A.	Ann.	2	3,400	—	—	12,500	N.A.	N.A.	—	N.A.	N.A.	N.A.	111.4	34.7	1,207	2.82
Wright																					
J65–W–16 (B.S. Sapphire)	Tj.	Ax.	13	7.0 : 1	120.0	Ann.	2	7,700	—	—	8,200	N.A.	N.A.	—	N.A.	N.A.	N.A.	122.0	37.5	2,742	2.81
J65–W–18 (B.S. Sapphire)	Tj.	Ax.	13	7.0 : 1	120.0	Ann.	2	10,500*a*	—	—	8,200	N.A.	N.A.	—	N.A.	N.A.	N.A.	182.0	37.5	3,425	3.07*a*
U.S.S.R.																					
Klimov VK–1A (in MiG–17)	Tj.	C.	1	4.5 : 1	N.A.	9	1	7,590*a*	—	—	13,000	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	50.3	*1,980*	*3.83*
Type 37V (in twin-jet Type RV) ‡	Tj.	Ax.	N.A.	N.A.	N.A.	N.A.	N.A.	8,818	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
TRD Type RS7F (in E–66 delta)	Tj.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	13,118	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Mikulin RD–3M (in Tu–104A)	Tj.	Ax.	8	*6.8 : 1*	*278.0*	Cann.	2	19,180	—	—	4,700	*0.90*	N.A.	—	N.A.	N.A.	N.A.	*200.0*	*54.0*	*5,100*	*3.76*
Mikulin M–209 (in Tu–16)	Tj.	Ax.	8	N.A.	N.A.	Cann.	2	*18,040*	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	*200.0*	*54.0*	*5,500*	*3.3*
Type 31 (in T.431)	Tj.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	19,840	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Type D–15 (in four-jet 201M and 103M)	Tj.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	28,660	—	—	N.A.	N.A.	N.A.	—	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Kuznetsov NK–4	Tp.	Ax.	14	*6.5 : 1*	N.A.	Ann.	3	N.A.	4,000	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Ivchenko AI–20 (in Il–18 and An–10)	Tp.	Ax.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4,000	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Kuznetsov NK–012M (in Tu–114)	Tp.	Ax.	14	13.0 : 1	137.0	Cann. 12	5	2,645	12,000	N.A.	9,250	0.573	N.A.	N.A.	N.A.	N.A.	N.A.	236.2	45.3	5,070	2.37
Soloviev TB–2–BM (in Mi–6)	S.T.	Ax.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4,700	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

Note.—Data in italics are estimated or unofficial. Abbreviations.—Ann., annular; Ax., axial; B.P., by-pass engine; C., centrifugal; Cann., cannular; G.G., gas generator; N.A., not available; S.T., shaft-turbine engine; Tf., turbofan; Tj., turbojet; Tp., turboprop; * lb. thrust, s.h.p., e.h.p. or g.h.p. as applicable to respective type of engine; ‡ may be engine fitted in MiG-19 and Yak-25, reported previously as VK-5 or M-205; *a*, with afterburner; *b*, less tailpipe; *c*, e.h.p.; *d*, compressor r.p.m.; *e*, power turbine r.p.m.; *f*, with reduction gear; *g*, gas h.p.; *h*, with reverser and sound suppressor; *w*, with water injection.





Left, the General Electric CJ-805-24 turbofan above, the Fiat 4700; and right, the Napier Eland powerplant with Blackburn Palouste air starter.

International Powerplant Data . . . .

ROCKET ENGINES

Engine Make and name	Duty	No. of comb. chamb.	Propellents: Oxidant	Propellents: Fuel	Propellents: Coolant	Max. thrust	Propellent supply means	Normal firing time	Overall dimensions: Length	Overall dimensions: Width	Dry weight
						lb.		sec.	in.	in.	lb.
FRANCE											
S.E.P.R.											
844	A.F.	1	Nitric acid	Kerosene	N.A.	3,308	Mechanical drive	A.T.	129.0	43.4	452 (pack)
2020	M.P.	1	Nitric acid	Furaline or Tx.	N.A.	2,975	Press. tanks	31	146.5	26.4	955
SWEDEN											
Svenska Flygmotor											
VR3	A.F.	1	H.T.P.	Gasoline	H.T.P.	5,720	N.A.	A.T.	39.4	11.8	165
UNITED KINGDOM											
Bristol Siddeley Engines											
PR.23	M.T.	1	H.T.P.	Kerosene	—	500	—	A.T.	39.0	6.5	32
Gamma Mk. 201	M.P.	4	H.T.P.	Kerosene	H.T.P.	19,000	Turbo-pumps	A.T.	38.0	36.0	700
de Havilland											
Spectre D.Spe.5	A.F.	1	H.T.P.	Kerosene	H.T.P.	8,000	Turbo-pumps	A.T.	56.5	24.0	N.A.
Spectre D.Spe.4	A.T.O.	1	H.T.P.	Kerosene	H.T.P.	8,000	Turbo-pumps	N.A.	59.2	21.5	N.A.
Double Spectre D.Spe.D.1	A.F./M.P.	2	H.T.P.	Kerosene	H.T.P.	16,000	Turbo-pumps	A.T.	58.6	36.6	N.A.
D. Napier and Son											
Triple Scorpion	A.F./M.P.	3	H.T.P.	Kerosene	H.T.P.	7,000–9,000	Turbo-pumps	A.T.	35.0	21.5	295
Rolls-Royce											
All current rockets secret											
U.S.A.											
Aerojet-General											
LR91-AJ-1	M.P.	1	Liquid oxygen	RP-1	N.A.	60,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
LR87-AJ-1	M.P.	2	Liquid oxygen	RP-1	N.A.	300,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
Bell Aircraft											
Hustler	M.P.	1	Nitric acid	JP-4	N.A.	15,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
Nike-Ajax engine	M.P.	1	Nitric acid	Aniline	—	2,600	N.A.	35	18.5*	6.5*	20*
Pratt & Whitney											
LR115	M.P.	1	Liquid oxygen	Liquid hydrogen	Fuel	15,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
Reaction Motors (Thiokol)											
LR11-RM-5	A.F.	4	Liquid oxygen	Kerosene	Fuel	6,000	Turbo-pumps	A.T.	*56.0*	*19.0*	*210*
XLR99-RM-2 Pioneer	A.F.	1	Liquid oxygen	Ammonia	N.A.	50,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
LR44-RM-2 Guardian	M.P.	1	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Patriot	M.P.	1	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
TU205	M.P.	2	N.A.	N.A.	N.A.	200	N.A.	N.A.	N.A.	N.A.	N.A.
Rocketdyne											
A-7	M.P.	1	Liquid oxygen	Alcohol	N.A.	75,000	Turbo-pumps	A.T.	131	70.0	1,450
S-3D (LR79-NA-9 (MB-3) similar)	M.P.	1	Liquid oxygen	RP-1	N.A.	150,000	Turbo-pumps	A.T.	*144*	N.A.	*2,000*
H-1	M.P.	1	Liquid oxygen	RP-1	N.A.	162,500	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
LR 89-NA-3 / MA-3	M.P.	1	Liquid oxygen	RP-1	N.A.	165,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
LR105-NA-3 / MA-3	M.P.	1	Liquid oxygen	RP-1	N.A.	60,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
E-1	M.P.	1	N.A.	N.A.	N.A.	400,000	Turbo-pumps	A.T.	N.A.	N.A.	N.A.
F-1	M.P.	1	N.A.	N.A.	N.A.	1,000,000	N.A.	A.T.	N.A.	N.A.	N.A.

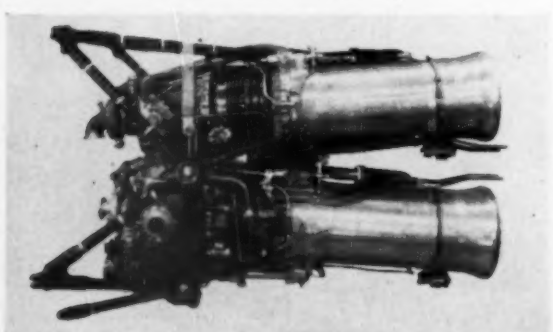
Abbreviations.—A.F., Aircraft flight rocket engine; A.T., according to tank capacity; A.T.O., assisted take-off unit; H.T.P., high-test hydrogen peroxide; M.P., missile powerplant; M.T., missile trimmer engine; N.A., not available; *, chamber only. Data in italics are estimated.

RAMJETS

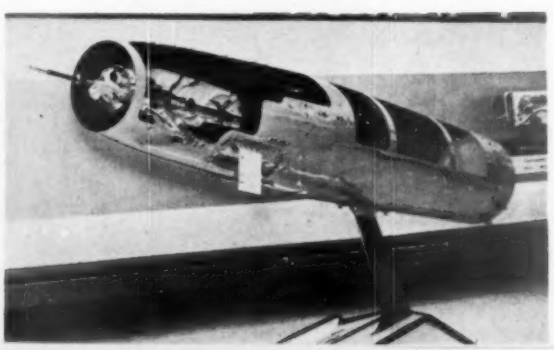
Make and name	Duty	Fuel	Performance: Thrust	Performance: Speed	Performance: Height	Performance: Consumption	Dimensions: Length	Dimensions: Diameter	Dry weight
			lb.		ft.		in.	in.	lb.
FRANCE									
Nord-Aviation									
ST.600 Sirius (in Nord CT.41 target)	M.P.	Kerosene	13,225	M=2	S.L.	1.8–2.2 lb./ton s.t./sec.	165.35	25.39	313
Griffon engine (in Nord 1500 Griffon)	A.F.	Kerosene	7,400	M=2	50,000	N.A.	N.A.	54.0	Integral
UNITED KINGDOM									
Bristol Siddeley Engines									
Thor BT.2 (in Bristol/Ferranti Bloodhound)	M.P.	Kerosene	*16,500*	M=3	S.L.	N.A.	94.5	15.75	N.A.
BRJ-801	M.P.	Kerosene	N.A.	N.A.	N.A.	N.A.	N.A.	18.0	N.A.
U.S.A.									
Hiller Aircraft									
8RJ2B (in Hiller YH-32 Hornet)	A.F. (Hel.)	Kerosene	40	—	S.L.	1 gal./min.	21.3	8.4	12.7
Marquardt Aircraft									
RJ30-MA-6	—	Kerosene	1,450	subsonic	S.L.	N.A.	87.25	20.0	126
RJ43-MA-3 (in Boeing IM-99A Bomarc)	M.P.	Kerosene	11,500	M=2.8	S.L.	N.A.	145.0	28.0	485
RJ43-MA-7 (in Boeing IM-99B Bomarc)	M.P.	Kerosene	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
RJ59	M.P.	Kerosene	N.A.	N.A.	N.A.	N.A.	N.A.	*36.0*	N.A.

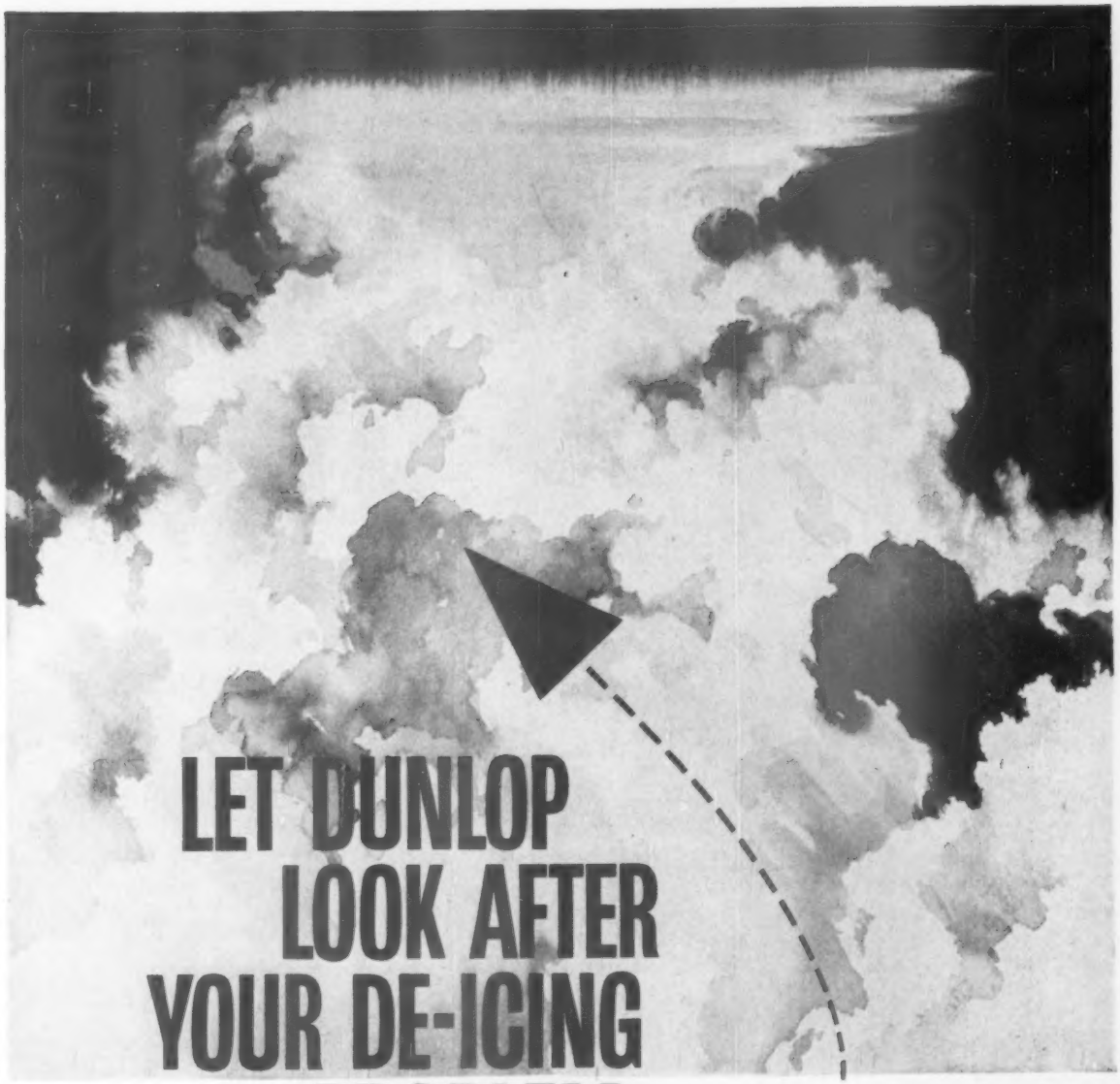
Abbreviations.—A.F., Aircraft flight ramjet engine; M.P., Missile powerplant; N.A., not available; S.L., Sea level.

de Havilland Double Spectre



Bristol Thor ramjet.





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International Powerplants Data . . . .

PISTON ENGINES

Engine Make and name	Type	No. of cyls.	Dimensions: Swept volume	Length	Width	Height	Dry weight	Comp. ratio	Performance: Take-off b.h.p.	Take-off r.p.m.	Max. continuous b.h.p.	Max. continuous r.p.m.	Max. continuous ft.	Fuel consumption
CZECHOSLOVAKIA			cu. in.	in.	in.	in.	lb.		b.h.p.	r.p.m.	b.h.p.	r.p.m.	ft.	g.p.h.
Walter														
Minor 4-III	I.L.	4	247.87	40.63	15.7	24.9	199	6 : 1	105	2,500	N.A.	N.A.	N.A.	0.49 lb.
Minor Sc. (M-332)	I.L.	4	247.87	43.4	16.7	24.7	225	6.3 : 1	140	2,700	115	2,550	S.L.	0.45 lb.
Minor 6-III	I.L.	6	364.31	49.21	17.49	25.16	280	6 : 1	160	2,500	N.A.	N.A.	N.A.	0.49 lb.
Praga														
Doris B	H.O.	6	437.36	48.38	36.81	24.06	436	7 : 1	220	3,000	200	2,900	S.L.	0.46 lb.
FRANCE														
Ardem														
(Druine) 4 CO 2	H.O.	4	72.62	16.0	30.0	25.0	133(P)	6.6 : 1	30.7	3,000	N.A.	N.A.	N.A.	1.88
Potez														
4-E.00	H.O.	4	209	27.1	30.1	24.8	203	7 : 1	96	2,530	90	2,475	S.L.	0.50 lb.
4-D.34	I.L.	4	352	48.0	20.87	28.35	403	7.6 : 1	260	2,550	205	2,400	3,000	0.49 lb.
Snecma														
(Bristol) Hercules 758	2R.	14	2,360	N.A.	52.0	52.0	2,175	7 : 1	2,040	2,800	1,670	2,500	5,000	N.A.
Renault 12T	I.L.	12	N.A.	53.7	19.6	29.7	N.A.	N.A.	600	3,300	506	3,250	7,850	18.4
GERMANY														
Porsche														
678/1	H.O.	4	96.5	N.A.	N.A.	N.A.	187	7.5 : 1	65	4,500	55	4,200	S.L.	3.41
678/4	H.O.	4	96.5	N.A.	N.A.	N.A.	225	9 : 1	75	4,600	70	4,500	S.L.	4.4
INDIA														
Hindustan														
P.E.90H	H.O.	4	192.23	32.0	31.5	21.25	180	6.7 : 1	90	2,600	N.A.	N.A.	N.A.	N.A.
ITALY														
Agusta														
G.A.40	H.O.	2	90.68	24.09	30.9	15.35	104	7.5 : 1	42	2,700	N.A.	N.A.	N.A.	N.A.
G.A.70/0 (and 70/V*)	H.O.	4	140.3	29.53	29.33	23.58	150	7.5 : 1	86	3,500	N.A.	N.A.	N.A.	N.A.
JAPAN														
Kawasaki														
KAE-240	H.O.	6	448	N.A.	N.A.	N.A.	440	N.A.	260	3,400	N.A.	N.A.	N.A.	N.A.
POLAND														
Narkiewicz														
WN-1	H.O.	4	176	28.26	32.2	23.3	128	6.3 : 1	65	2,500	58	2,400	S.L.	0.48 lb.
WN-3	R.	7	820	34.9	43.5	43.5	530	6.2 : 1	340	2,500	285	2,250	S.L.	0.48 lb.
WN-6	H.O.	6	421	42.9	32.67	16.53	346	6.5 : 1	180	2,600	160	2,500	S.L.	0.48 lb.
WN-7	H.O.	4	281	37.0	32.67	20.47	232	6.5 : 1	125	2,500	110	2,350	S.L.	0.47 lb.
SPAIN														
Enma														
Flecha F-IV-1	H.O.	4	211	31.84	31.64	28.65	220	7 : 1	93	2,600	N.A.	N.A.	N.A.	0.51 lb.
Tigre G-IV-B5	I.L.	4	386	47.67	15.76	29.82	323	6.5 : 1	150	2,300	N.A.	N.A.	N.A.	0.50 lb.
Alcion A-1	R.	7	446	45.9	33.46	33.46	495	6.5 : 1	275	3,000	250	2,800	4,920	0.46 lb.
Sirio S-2	R.	7	1,090	45.7	44.1	44.1	785	6 : 1	500	2,300	440	2,100	6,890	0.50 lb.
Beta B-4	R.	9	1,820	46.0	54.6	54.6	1,070	6.4 : 1	775	2,200	750	2,100	9,500	0.55 lb.
UNITED KINGDOM														
Alvis														
Leonides 514/8A	R.	9	718.6	54.4	41.5	41.5	735	6.5 : 1	560	3,000	495	2,900	3,750	23.5
Leonides 521/2*	R.	9	718.6	54.96	41.5	41.5	790	6.5 : 1	515	3,000	405	2,800	8,250	N.A.
Leonides 531/8	R.	9	783.3	54.4	43.0	43.0	860	6.5 : 1	640	3,200	585	3,000	2,500	25.0
Leonides Major Mk. 155*	2R.	14	1,118.6	54.9	38.9	38.9	1,110	6.8 : 1	755min.	2,900	705	2,900	6,750	38.5
Blackburn														
Bombardier 702/208	I.L.	4	398	45.9	18.6	31.5	375	7 : 1	180	2,600	155	2,300	1,250	10.5
Bristol Siddeley														
Centaurus 661	2R.	18	3,270	74.6	55.3	55.3	3,460	7.2 : 1	2,625	2,800	2,265(M) 2,110(S)	2,500(M) 2,500(S)	5,500(M) 12,000(S)	85.0
De Havilland														
Gipsy Queen 70/2	I.L.	6	622	71.75	19.56	33.23	690	6.5 : 1	380	3,000	355	2,700	4,250	17.5
Gipsy Major 215*	I.L.	4	416	51.0	16.8	29.8	415	7.25 : 1	215	2,850	207	2,700	S.L.	10.3
Rolls-Royce														
Griffon Mk. 57	I.L.	12	2,240	83.5	31.8	N.A.	2,115	6 : 1	2,435	2,750	1,355(M) 1,285(S)	2,400(M) 2,400(S)	6,250(M) 12,500(S)	124.0
U.S.A.														
Continental														
A65-8F	H.O.	4	171	30.41	31.50	20.34	167	6.3 : 1	65	2,300	65	2,300	S.L.	4.0
C85-12F	H.O.	4	188	31.26	31.50	21.22	179	6.3 : 1	85	2,575	85	2,575	S.L.	N.A.
C90-12F	H.O.	4	201	31.26	31.50	24.19	186.5	7 : 1	95	2,625	90	2,625	S.L.	N.A.
O-200-A	H.O.	4	201	28.53	31.62	23.25	190	7 : 1	100	2,750	100	2,750	S.L.	N.A.
O-300-A and B	H.O.	6	301	39.75	31.50	23.25	276.5	7 : 1	145	2,700	145	2,700	S.L.	0.50 lb.
O-470-K and L	H.O.	6	471	36.03	33.60	27.75	404	7 : 1	230	2,600	230	2,600	S.L.	0.52 lb.
IO-470-D	H.O.	6	471	43.31	33.60	19.75	426	8.6 : 1	260	2,625	260	2,625	S.L.	N.A.
FSO-526-A*	H.O.	6	526	50.33	34.64	28.54	560	6 : 1	270	3,200	270	3,000	S.L.	N.A.
Franklin														
335 6V4-200-C32*	H.O.	6	335	29.03	N.A.	N.A.	333	8.5 : 1	200	3,100	N.A.	N.A.	N.A.	0.52 lb.
Lycoming														
O-235-C1	H.O.	4	233	29.56	32.0	22.53	237	6.75 : 1	115	2,800	108	2,600	S.L.	0.52 lb.
O-290-D2B	H.O.	4	289	29.56	32.24	22.81	264	7 : 1	140	2,800	135	2,600	S.L.	6.5
O-320-B1A	H.O.	4	319.8	29.56	32.24	23.12	278	8.5 : 1	160	2,700	160	2,700	S.L.	8.2
O-360-A1A	H.O.	4	361	29.56	33.37	24.72	285	8.5 : 1	180	2,700	180	2,700	S.L.	N.A.
VO-360-A1A*	V.O.	4	361	29.79	33.37	21.92	298	8.5 : 1	180	2,900	180	2,900	S.L.	0.545 lb.
O-435-23B*	H.O.	6	434	34.73	33.32	25.19	403	7.3 : 1	255	3,400	245	3,200	S.L.	20.0
GO-480-G2D6	H.O.	6	479.7	40.59	33.12	28.02	442	8.7 : 1	295	3,400	285	3,100	S.L.	13.5
IGSO-480-A1A6	H.O.	6	479.7	47.56	33.12	23.29	496	7.3 : 1	340	3,400	320	3,200	S.L.	15.8
O-540-A1A5 and A2B	H.O.	6	541.5	37.22	33.37	25.81	396	8.5 : 1	250	2,575	250	2,575	S.L.	12.0
VO-540-A1A*	V.O.	6	541.5	34.73	34.14	28.18	435	7.3 : 1	310	3,300	305	3,200	S.L.	N.A.
VSO-580-A1A*	V.O.	8	578	49.20	33.18	30.75	574	7.3 : 1	400	3,300	350	3,000	5,000	N.A.
McCulloch														
4318E	H.O.	4	100	27.00	22.00	15.0	77	7.8 : 1	72	4,100	72	4,100	S.L.	0.90 lb.
TC6150	H.O.	6	150	44.50	22.00	17.0	142	7.8 : 1	120	N.A.	86	N.A.	30,000	0.80 lb.
Nelson														
H-63B (YO-65)	H.O.	4	63	18.00	25.00	17.5	79.9	8 : 1	43	4,000	43	4,000	S.L.	5.5
Pratt & Whitney														
R-985	R.	9	985	N.A.	46.10	46.10	684	6 : 1	450	2,300	450	2,300	2,300	N.A.
R-1340 SIH1	R.	9	1,344	43.01	51.80	51.8	877	6 : 1	600	2,250	550	2,200	8,000	N.A.
R-2000 DS	2R.	14	2,004	59.66	49.10	49.10	1,585	6.5 : 1	1,450	2,700	1,200	2,550	6,400	N.A.
R-2800 CB17	2R.	18	2,804	81.40	52.80	52.80	2,390	6.75 : 1	2,500†	2,800	1,900(M) 1,750(S)	2,600(M) 2,600(S)	7,000(M) 13,500(S)	N.A.
Wright														
R-1300-3	R.	7	1,300	49.68	50.45	50.45	1,080	6.2 : 1	800	2,600	700	2,400	S.L.	0.70 lb.
R-1820-82	R.	9	1,823	50.10	55.74	55.74	1,469	6.8 : 1	1,525	2,800	1,275(M) 1,125(S)	2,500(M) 2,500(S)	3,500(M) 10,600(S)	0.68 lb.
R-3350 TC18EA6	2R.	18	3,347	89.53	56.59	56.59	3,675	6.7 : 1	3,440	2,900	2,920(M) 2,450(S)	2,650(M) 2,600(S)	4,800(M) 16,400(S)	N.A.
U.S.S.R.														
ASh-82T	2R.	14	2,513	79.13	51.18	51.18	2,250	6.9 : 1	1,900	2,600	1,630	2,400	5,250	N.A.
M-11FR	R.	5	522.6	37.4	42.5	42.5	353	5.0 : 1	160	2,000	N.A.	N.A.	N.A.	0.55 lb.

Abbreviations.—H.O., horizontally opposed; I.L., in-line; lb., lb./b.h.p./hr.; (M), medium supercharger speed; N.A., not available; (P), with propeller and exhaust stubs; (S), fast supercharger speed; S.L., sea level; R., radial; *, helicopter engine; †, with coolant injection; V.O., vertically opposed.

The Future for Rocket Propellents

by W. N. Neat, B.A., A.F.R.Ae.S.*

AERONAUTICAL history has been characterized by one controversy after another—controversies about apparently competing ways of achieving the same result. Examples which immediately spring to mind are those of the biplane v. the monoplane; wood v. metal as a structural material; and the centrifugal v. the axial compressor.

In most cases, requirements getting progressively more difficult have eventually ruled out one or other possible solution to settle the argument once and for all. On other occasions, however, a compromise has been reached—it being gradually accepted that for certain requirements one approach was the better, while for others the alternative solution would prove the more acceptable.

In the field of rocket engines the controversy, which has been raging for some time and is certainly not yet settled, concerns the correct choice of propellents, primarily whether they should be solid or liquid.

There are certain applications where the choice, on a first analysis at any rate, would hardly appear to warrant any argument. For the small or medium size fixed-thrust fixed-duty, expendable rocket motor, the use of solid propellents would seem the obvious choice. On the other hand, for the repeated-use variable-thrust rocket motor intended for a mixed-power-plant fighter the use of liquid propellents was, and still would be if the choice had to be made again today, obligatory.

It is for the specific requirement of the long-range military weapon that the controversy begins to have more meaning and importance. It would appear that the Americans (at one time at any rate) had made up their minds on this subject, for while the present-generation weapons, Atlas and Titan are liquid propelled, Polaris and the next phase multi-purpose missile, Minuteman are to be solid propelled. Admittedly Polaris is designed for a particular duty which, perhaps, makes solid propellents a more obvious choice; but the choice of solid propellents for Minuteman is a better indication of serious intentions.

* Chief engineer de Havilland Engine Co., Rocket Division.

There are a number of advantages which have been put forward for solid propellents which no doubt have dictated this policy. The two most important are those of instant readiness and reliability.

Let us, however, consider the question of readiness against a background of the need for the liquid-propellent systems to be fuelled within a few hours of launch. Complex guidance and control systems require a definite period of servicing, checking adjustment and warming up immediately prior to use, which may well mask the time taken to fill the missile with liquid propellents and, therefore, reduce the argument on this score in favour of the solid. A more valid argument may be, however, that a missile launching site is complicated enough anyway and might be rendered rather less so if all the fuelling equipment necessary for liquid propulsion were not required.

So far as reliability is concerned, it would seem reasonable to assume that the solid-propellent motor with no rotating and few moving parts would always tend to be inherently more reliable than the liquid-propellent counterpart with its complicated control and feed system. However, reliability is a relative matter and there is no doubt that liquid-propellent engines can be made reliable enough for all practical purposes. This achievement is likely to come with the accumulation of more test experience, no doubt accelerated by efforts to simplify engines wherever possible.

The question of first cost has been raised as another argument in favour of the solid unit. Accepting the fact that the argument holds good, its importance should not be over-accentuated. The cost of the powerplant of a large missile is small in comparison with the cost of the rest of the missile, especially its warhead, together with the capital cost of the launching site and all the equipment which goes with it.

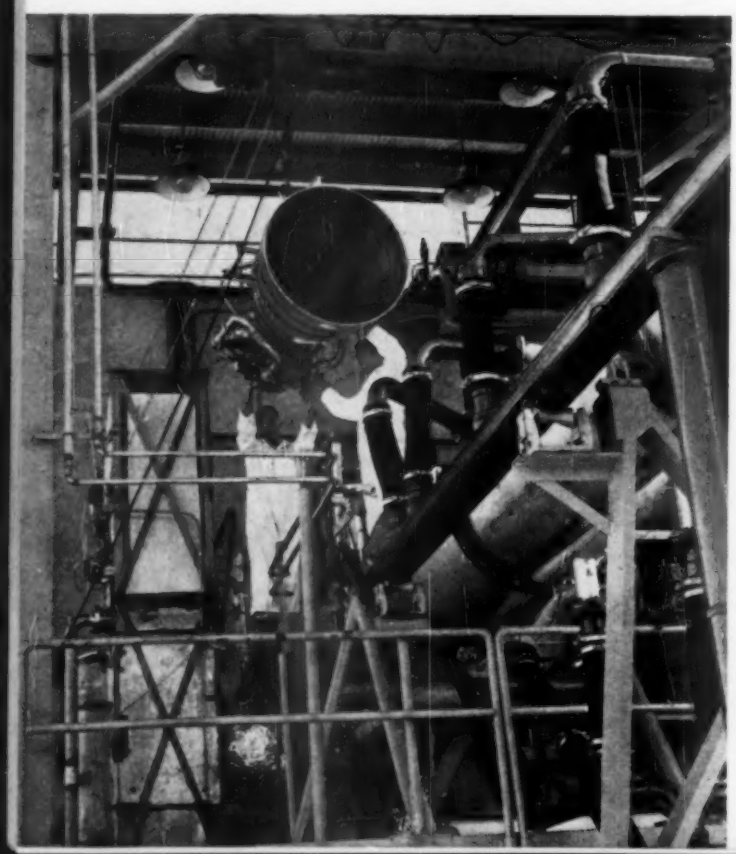
How can the liquid-propellent motor be adapted to overcome at least some of its disadvantages compared with its solid competitor? The question of reliability has already been briefly mentioned—the liquid unit will inevitably grow more reliable with increased experience and the process of simplification.

Regarding the question of instant readiness two methods are possible. First, an oxidant can be chosen which is readily storable compared with the highly volatile liquid oxygen at present in use. In this context, nitrogen tetroxide appears to be a distinct possibility, giving roughly the same motor performance as liquid oxygen. However, the use of nitrogen tetroxide may demand some new techniques, together with some redesign of any tankage system since the volumetric mixture ratios required are likely to be rather different than liquid oxygen/kerosene systems at present in use.

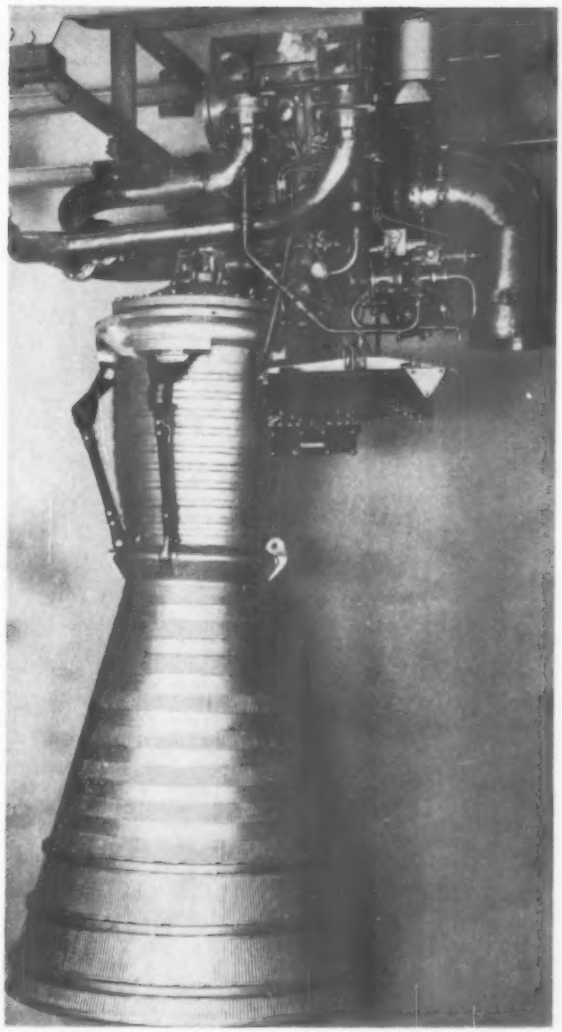
It seems unlikely, therefore, that existing missiles could be conveniently converted to use storable propellents. As an alternative, however, it may be possible to retain liquid oxygen and modify the fuelling system so that the missile can be kept filled and serviceable for long periods of time, thus approximating very closely to instant readiness.

In smaller sizes complete "packageability," which is really a more advanced stage of storability, can be achieved again by the correct choice of liquid propellents. Reaction Motors in the United States have done considerable work in this field and at least one small missile, hitherto powered by a solid-propellent unit, has been re-engined with a liquid packaged unit. The advantages claimed for the change are higher performance, less temperature sensitivity and easier storage.

It is when increased performance is required that solid propellents are unlikely to compete with liquids. The performance of the best solid motors today is roughly comparable with the liquid oxygen/kerosene system giving a practical sea-level specific impulse of about 250 sec. It seems likely that even a small increase on this would be difficult to achieve and may only be possible at the expense of some loss of storability and reliability.



ADVANCED ROCKET.—Liquid oxygen and liquid hydrogen are the propellents of this Pratt & Whitney XLR 115 rocket motor. In this view the motor is being prepared for a test in vacuum conditions, exhausting into the large tube on the right. Two of these motors will power the upper stage of the Centaur space vehicle.



LRBM POWERPLANT.—Two Rolls-Royce rocket motors of this type power the de Havilland Blue Streak LRBM; propellents are kerosene and liquid oxygen. The motor is based on a Rocketdyne design.

There are, however, some very promising liquid-propellent combinations which can handsomely exceed this performance figure—liquid hydrogen/liquid oxygen (with a practical S.I. of about 350 sec.) and liquid hydrogen/liquid fluorine (S.I. about 370 sec.) being perhaps the best known. Without doubt, there are still a number of problems outstanding in the handling and storage of hydrogen and fluorine, but already both systems have been demonstrated quite considerably—liquid hydrogen/liquid oxygen on quite a large scale as evidenced in the article on the Pratt & Whitney engine for the Centaur project, in THE AEROPLANE AND ASTRONAUTICS for January 8.

For military needs, a performance better than that achieved with liquid oxygen/kerosene or with solid propellents is unlikely to be required. The necessary ranges have already been met and the required weight of warhead carried; and a consolidation of the present position is most likely to be the order of the day.

For missions beyond the atmosphere and particularly for those into outer space this, however, is not true. While "conventional" rocket engines are still likely to be used for initial boost stages for a long time to come, the use of higher energy propellents in subsequent stages will pay very considerable dividends. In fact, some of the missions which, it has been openly stated, will be attempted during the next few years, can only be done economically with high-energy propellents.

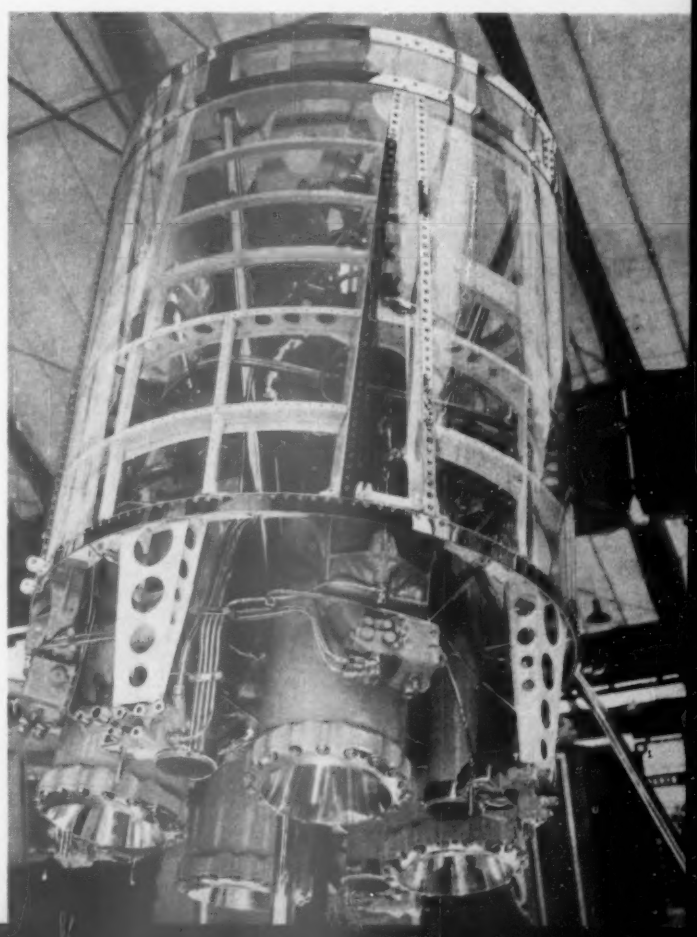
Assuming, therefore, that the conquest of space will continue as it undoubtedly will, the development of high-performance rocket engines is mandatory. Whether the slightly higher performance of fluorine will justify its use is debatable. In spite of its low density (which may not be such a serious problem as was once thought, especially when it is used in stages operating beyond the atmosphere) hydrogen used with oxygen may be the more attractive proposition. Quite apart from its use in a chemical rocket its possible application to nuclear propulsion, as well as the ramjet and gas turbine, would justify work being carried out with it.

An attempt to sum up these observations leads one to the following broad conclusions.

To begin with, there is no doubt that the development of both liquid- and solid-propellent units will go on unabated. Efforts will be made to improve the performance of solid units and to overcome the problems associated with their manufacture in large sizes. So far as liquid units are concerned, the accent will be on improved reliability, increased simplicity, and by the use of higher energy propellents, improved performance.

Attempts will be made to extend and consolidate relative fields of application, the solid unit in the large missile, the packaged liquid unit for various purposes at present met by the use of solids. It would appear that the propulsion requirements of the large ballistic missile can be met completely by the use of liquid oxygen and kerosene or by solid propellents. In view of the results already obtained there seems little justification to use more energetic propellents than these, and it seems more likely that efforts will be made to capitalize on the work that has already been done.

For space flight, quite different considerations apply. Increasing terminal velocity requirements, together with the need for heavier payloads, will demand improved powerplant performance. This can only be obtained by the use of more energetic propellents, most probably hydrogen and oxygen or hydrogen and fluorine, although the extra performance gain given by the latter combination may not warrant its extensive use, bearing in mind the technical difficulties of handling fluorine. On the other hand, work on liquid hydrogen is likely to be accelerated, not only because of its application to the chemical rocket engine, but also because of its possible use in the gas turbine and ramjet and in future nuclear rocket engines.



FOUR-IN-ONE.—The Bristol Siddeley Gamma which powers the Black Knight re-entry research vehicle is an HTP/kerosene motor giving a thrust of 16,400 lb. at sea level or 19,000 lb. above the atmosphere. It has four swivelling combustion chambers coupled in pairs for control of the missile.

International I

PROF. H. S. W. MASSEY, chairman of the British National Committee on Space Research, said at Burlington House, Piccadilly, on February 2, that the first satellite equipped with British instruments, to be launched into orbit by the American Scout rocket, would be called International I. Launched from Wallops Island, Virginia, late next year, the satellite would pursue an orbit lying between 200 and 600 miles, carrying it as far north as the latitude of Edinburgh and a similar distance in the southern hemisphere. At times it should be visible to the naked eye.

As reported last week, International I will be mainly concerned with investigating the ionosphere, the electrified layer in the Earth's atmosphere responsible for reflecting radio waves. It will also carry solar and cosmic radiation instruments. This equipment is now being worked on by various U.K. universities.

On some transits of the satellite across the sky, its path will be followed by an aircraft whose crew will make similar cosmic-ray measurements. Comparison of readings obtained in the aircraft with those of the satellite should determine how the atmosphere screens, and modifies, the primary radiation.

U.S. Moon Plans

A PROGRAMME of space-exploration covering the next 10 years was outlined before a Congressional Space Committee in Washington on January 28 by Mr. Richard Horner, representing the National Aeronautics and Space Administration.

In 1962, he said, N.A.S.A. hoped to launch two test versions of the Saturn booster with an initial thrust of 1.5 million lb. Between 1963 and 1964, it was hoped to land an unmanned vehicle on the Moon, and to follow this with a manned satellite travelling around the Moon and back to Earth between 1965 and 1967. It was hoped to put a man actually on the Moon's surface "some time after 1970."

N.A.S.A. is asking Congress for another £40,336,000 for the financial year beginning on July 1, bringing the total to more than £326,500,000. Mr. Horner told the Space Committee that N.A.S.A. planned 219 launchings in the years 1962 to 1969.

Atlas Weight Control

ONE of the least publicized aspects of the production of a modern ballistic missile is the effort which is constantly made to keep the total weight within fine limits. In the case of the Convair Atlas, for example, it is checked for weight between six and eight times during manufacture and preparations for launching. Exacting records are made of each component right down to the smallest measurable item. As weighing operations progress, minute checks are made of all missing parts for which figures must subsequently be added.

According to Mr. J. F. Conlin, of Convair-Astronautics engineering weights group, a pound in weight saved in production will add a mile of range, as a rough estimate. Applied to upper stages, the performance capabilities "spiral upward with similar weight reductions."

Before an Atlas leaves the factory, it is weighed complete on a special three-unit rig, consisting of two scales anchored in pits and a third mounted on a mobile track. Each scale has a capacity of 30,000 lb. and is accurate to within 1/20 of one per cent.

Overhead cranes lift the Atlas into the rig. Electric motors then rotate the missile 30° to the right and left. This operation helps to locate the centre of gravity, which must fall within specified limits at all times to ensure stability at launching and in flight.

Convair-Astronautics also maintain weight control units at Cape Canaveral. One rig there consists of three jacks fitted with special heads which lift the missile on its handling trailer. As it is lifted, weight data is transmitted electronically to a control panel.

Successful Pacific Rockets

RUSSIA announced on February 1 that the second multi-stage rocket, launched nearly 7,800 miles into the Central Pacific the day before, would end the present series of tests. The first Soviet test-firing was on January 20.

A Tass statement said the rocket's dummy final stage reached the Pacific at 17.58 hrs. G.M.T. on January 31. It was observed during flight in the atmosphere and was tracked at its fall by radiolocation and by optical and acoustic stations set up in ships. Some of these, it seems, were in the target area. "According to the data of the measurements, the high degree of control over the flight of the rocket has been confirmed yet again."

Dr. Vitaly Stepanov, of the U.S.S.R. Academy of Science's Institute of Oceanology, said that the two launchings had been so successful that no further tests would be necessary over the Pacific range. According to Prof. Dobronravov, the next test-firing will involve "carrying a package of instruments into outer space for further research."

Sputnik III Nears End

AUSTRALIAN scientists have predicted that Sputnik III, the 26-cwt. "orbital laboratory" launched by Russia on May 15, 1958, will re-enter the atmosphere and burn up early next month. The satellite was visible to the naked eye from southern Australia at the beginning of this month.

When originally launched, the apogee and perigee were 1,167 miles and 135 miles respectively and the period of revolution 105.95 min. Since then the shape of the orbit has been gradually contracting to a circle. Last November, the apogee had reduced to 537 miles and the period to 95.27 min.; and the Australians now report the nominal height as 140 miles.

During all this time, the Mayak radio has continued to function. Although the chemical batteries have been exhausted, the transmitter is being supplied from solar batteries.

At the beginning of the year, Sputnik III had completed 8,600 orbits of the Earth, covering a distance of over 239 million miles.

Thus, as well as providing a fund of information about conditions in near-space, the experiment has been a convincing demonstration of the high standards of instrument and electronic reliability which have been achieved by Soviet scientists, now apparently on the verge of sending probe vehicles to Mars and Venus.

First picture of the Titan production line at Martin's Denver factory showing the two-stage ICBM in various phases of assembly.

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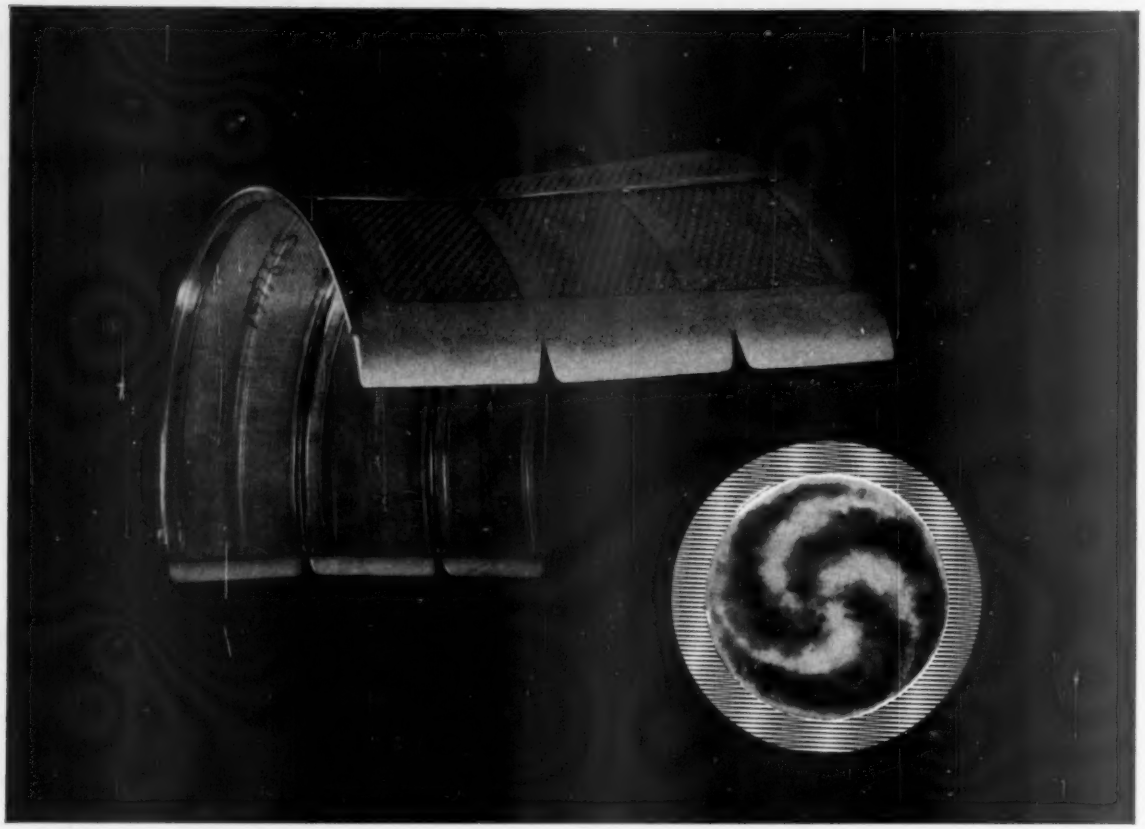

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Personal Flying

BACKYARD aviation is coming back into its own. Every other club airfield seems to conceal a hive of activity as somebody's dream aeroplane slowly takes shape. Certainly this is true of many places in Southern England, such as Eastleigh, Redhill, Stapleford, Thruxton and elsewhere. Even some of the larger manufacturing companies in the industry are now joining the party, with activity reported from Filton, Rearsby, Rochester and Weybridge.

But the renaissance of the light aeroplane movement will initially depend, almost certainly, on the growth of backyard aviation, as it did in the beginning. Unfettered by over-organization; free to develop its own ideas; and undeterred, perhaps, by their apparent impracticability, backyard aviation is unrivalled as a source for the design and construction of imaginative prototypes.

It is usually less successful, unfortunately, in the production and promotion of its aircraft. Quite often, promising designs have foundered in the turbulent depths of finance and production facilities. With their greater experience in these fields, the larger companies in the aircraft industry might well fulfil a function which will be useful to themselves and the light aeroplane movement by taking over some of the backyard aviation designs, and completing their development for production.

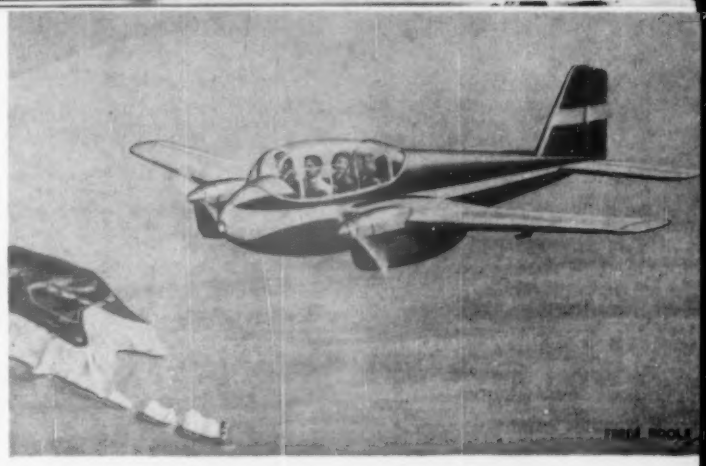
The cost of acquiring such prototypes would probably be considerably less than for the larger companies, with their massive overheads, to design them from scratch, although it may be necessary for some education to be provided through the R.Ae.C., the A.B.A.C. or the P.F.A., on the requirements for large-scale production. In the meantime, it is to be hoped that at least some of the backyard aviation projects will achieve production status without assistance.

• • •

As one of the places where unconventional things are afoot, or, more accurately, awing, the Hampshire Aero Club at Eastleigh has been reverberating to the whistle of the Wot-mounted turboprop. The little Currie biplane (pictured last week) is serving as a test-bed for the Rover 1S/60 gas-turbine, which has a promising application for light aircraft. The crux of its development for this purpose would appear to be the usual turboprop problem of airscrew-pitch control.

An excessively fine pitch, compared with that for flight, is required to avoid compressor stall during ground running. This can easily be achieved with a manually variable-pitch airscrew, but a simple linkage would seem to be required to provide some degree of automaticity in pitch control during flight.

On the other hand, the Rover gas-turbine has shown itself to be a remarkably good-tempered unit, and it may be possible to get away with manual operation of the normal piston-engine pitch-change sequences over a wider range of blade angles. Perhaps one of the propeller companies might like to exercise their ingenuity on this little problem.



HALCYON PROSPECT.—An artist's impression of the Hillbourne Halcyon, which is being built at Eastleigh, Hants., and is due to fly later this year.

If the technical snags can be cheaply overcome, the light turboprop unit will have much to offer, particularly in this country, where no low-powered aero-engines are being produced. The fuel consumption, at normal lightplane cruising altitudes, may be two or three times heavier for the turboprop, but this will be cancelled out (fuel subsidy apart) by the lower price of paraffin. Consumption may also be reduced by operating at, say, 10,000 ft., although this may require a P.P.L. instrument rating to penetrate the airways.

Vivian Bellamy of the Hampshire Aero Club, who, with the active help of the Rover company, is behind the turboprop Wot, is anxious to explore the potential of this powerplant for possible installation in the light twin which is being built at Eastleigh. Designed by R. J. Hillbourne, B.Sc., the B.H.I Halcyon is a three/four-seat mid-wing monoplane with a retractable nosewheel undercarriage.

Of wooden construction, the prototype will be powered by two 65 b.h.p. Walter Mikron engines, and has a design gross weight of only 1,800 lb. The fuselage, which is of oblate spheroidal section, is being built of cold-moulded diagonally wrapped ply in a similar manner to marine practice; it is, in fact, being built at a boatyard. The mainplanes are of conventional wooden construction, with metal-framed flaps, and the centre-section is nearing completion.

Estimated cruising speed of the prototype, which should fly later this year, is 130 m.p.h., and with four occupants, the range will be about 300 miles. Dimensions are: span, 30 ft. 5 in.; length, 23 ft. 7 in.

Gliding Notes

by Dr. A. E. Slater

PHILIP WILLS, back from an F.A.I. meeting, has brought the news that the Gliding Commission have reversed their decision to hold Championships every three years instead of two. In future they will be every two years as before.

News from Germany is that 26 nations have entered so far, including Australia, Canada, Iceland (for the first time), Rumania and the U.S.S.R. Argentina and Japan have not yet entered. Among 84 entries, 23 are in the Open Class and 61 in the Standard Class.

In the German team Ernst-Günter Haase, the present World Champion, will be flying a plastics Phoenix FS-34, and in the Standard Class will be Heinz Huth and Hans Böttcher, each with a Ka-6. The German Aero Club is being subsidized by the Ministry of the Interior to help with the expenses of the meeting.

The Swiss team is stated to consist of René Comte with an Elfe-M and Bernhard Müller with a Weihe in the Open Class, and Alexandre Grünisch with a Fauvette and Kurt Baumgartner with a Polish Mucha Standart in the Standard Class—but one of the four will have to be dropped. Josef Widmer is reserve pilot. Hans Nietlispach and Niklaus Dubs cannot take part "for professional reasons," although Nietlispach is the 1959 national champion.

From France comes news that their team will consist of MM. Labar and Lacheny in the Open Class, one of them with a Sevimia 30 if tests prove satisfactory; and M. Barbera in the Standard Class with a Fauvette. Possible reserve pilots are MM. Weysse, Trubert or Marchand.

E. "Boet" Dommisse, who represented South Africa last year, writes that his country is not sending a team, though he hopes to come as a spectator.

* * *

This year's Danish team, Per Weishaupt writes, will have Harald Jensen in the Open Class with a Lo-150. Jensen, always known as "Cowboy," was in the United States two years ago, when he took part in their national contests and finished 3rd with a Lo-150 lent him by Wolf Hirth.

In the Standard Class, Denmark will again be represented by Niels Sejstrup and Joergen Friis, who both flew Eon Olympias in 1958 but this time will have respectively a Rhönsegler (otherwise Ka-6, which won the OSTIV prize) and a Mucha Standart, the Polish type in which Adam Witek became Standard Class champion. Aage Thomsen, who flew in the Open Class last time, is reserve pilot, and Aksel Feddersen team captain.

The Swedish team's pilots will be Per Axel Persson, the 1948 World Champion, who finished 2nd in the Standard Class last time; Irve Silesmo, former national champion; and Sven Jonssen; with Olle Haakansson as captain.

For United States participation in the Championships, both Dick Johnson and Dick Schreder are building new sailplanes. They come first and second on the seeded list, followed by Paul Bikle and Lyle Maxey. Schreder's machine is to have area-changing flaps, and he is putting a 10-h.p. engine in it temporarily to help him to get plenty of training practice.

The Netherlands team will have Frits Seyffert, winner of last year's national contest, in the Open Class with a Skylark 3; and two entries in the Standard Class, each with a Ka-6; Willem Toutenhoofd (the first syllable is pronounced as in English, and the last rhymes with "loafed"), and Sipko Andreae, who flew in the Nationals unofficially but put up the highest score next to Philip Wills.

Correspondence

Fantasy, Not Fact

THE views expressed in your Personal Flying feature of January 29 on the recent *Sunday Express* article do, of course, contain an element of logic but they also show a deplorable pessimism and defeatism in keeping with a journal that seems already to have part abandoned aeronautics in favour of astronautics. Robert Glenton's article was certainly lyrical but I fail to see how it could do more harm than good. The light aircraft business desperately needs a boost and even if we, like your journal, travel slightly into the realms of fantasy in getting it, why shouldn't we?

I can vouch for the fact that interest in the Jodel has been enormously stimulated by the article and at worst it has made a larger number of people think about flying for the first time, and at best may lead to a number of sales and the introduction of some new faces to this pathetically undersubscribed business of flying oneself for business or just fun—when the weather does permit, which is really quite often.

For heaven's sake don't let's frighten them away before they start—we should do everything to swell their number till the movement has a voice in its own affairs which must be heeded and from which will spring the improved facilities which you claim to seek.

Croydon, Surrey. W. V. FITZMAURICE.
(Rollason Aircraft and Engines, Ltd., Secty.)

Famous Lancasters

I AM trying to compile the history of the last two Lancasters in England which are "S. Sugar" R.5868, the Air Ministry's famous specimen which has completed 137 operations, and "F. Freddie," which resides in the Imperial War Museum in Lambeth. Both aircraft served with 467 (R.A.A.F.) Squadron.

"S. Sugar" bears the striking phrase NO ENEMY PLANE SHALL FLY OVER REICH TERRITORY. HERMAN GORING. "F. Freddie" has a representation of the Disney character Goofy, beneath which on a scroll is the wording "Old Fred"; on each side of which is an R.A.A.F. flag.

I should like to appeal to anybody who served with 407 Sqn., who maintained either aircraft, or has any details however small, to get in touch with me.

Chingford, Essex. G. P. TRANT.

Photographs Wanted

A HISTORY of Royal Air Force, Scampton, is being compiled and we would be most grateful if any of your readers will supply copies of photographs taken at Scampton in past years. We would be happy to receive any other material: copies of official programmes for example.

Any negatives or prints loaned would be carefully handled and returned promptly.

Royal Air Force, Scampton. T. STAFFORD (Sqn. Ldr.).

Very Low Fares

THE V.L.F. controversy has been going on long enough. Hunting-Clan and others have been waiting a year or more for a decision. Is it not time that we tried to be smart?

If an application for V.L.F. on a route has been made, and accepted pending a decision, then why not charge the full fare on paper and the V.L.F. in actual cash?

A document, signed by the passenger, promising full payment on demand if the V.L.F. application is refused, would probably make it legal. The airline might never be able to recover the balance from all its passengers, but would they have lost anything?

Old Byfleet, Surrey. KEN TREMAIN.

Profitability Demonstrated

IN his article "1959—the Turning Point," R. H. Ayers, in your issue of January 8, implied inefficiency in BEA when he mentioned private enterprise "with its more efficient administrative organization."

Statements of this sort are made from time to time with a remarkable lack of authority and there is always the possibility that if made with sufficient frequency they may be believed. For this reason I ask you whether it is really fair to BEA and your readers to imply inefficiency without giving supporting facts.

In the same issue of your magazine an article on "Traffic Estimates for 1959" gave an estimate of the unprofitable state of the World's airlines taken together during that year, and it was there stated that according to ICAO figures, the World's airlines were running at a loss.

I do not need to point out to you that BEA is one of the few airlines in the World which, during the difficult years of 1958-59, produced a profit after paying interest on the whole of its working capital, a disability from which private enterprise does not suffer. In fact, as many of your readers will know, BEA has shown consistent profits for the past five years.

I think it fair to say that our profitability at a time when the World's airlines are losing money scarcely argues inefficiency in its administrative organization.

London, S.W.1. WILLIAM SIMPSON,
(Chief Public Relations Officer, BEA).

Working Dress

I HAVE noticed on my visits to Ministry Research Establishments such as the R.A.E. and the R.R.E. that the standard of male dress appears to be a greeny tweed sports jacket, woollen jumper and grey flannel or corduroy trousers. There seem to be few exceptions to this rule.

Is it considered to be the hall-mark of "boffin" status, and if anyone appears with a neat dark lounge suit, white shirt and handkerchief, with tidy hair and clean shoes, would he be considered eccentric?

Hazelwood, Derby. H. E. WEST.

Groundabout

Genny Wren. If you yearn to learn, if you want the inside gen., watch this column. Nowhere else, for instance, will you find the *real* reason why a three-engined layout was adopted for the D.H.-Airco 121. Two engines weren't enough, four were too many. And that's not all. I can also reveal that the 121 (what a pity its design number wasn't, say, 111 or 123) will *not* be named the Caravickers.

*

The Flying Dollar. That great All-American eccentric, Howard Hughes, one of whose hobbies is buying expensive aeroplanes he doesn't really want, is said to have made out a cheque for $100,000 too much when buying a two-million dollar jetliner. When the mistake was pointed out, he is alleged to have said, "O.K.—give me the change in Piper Cubs."

*

Could Be. I wonder if it was Howard Hughes who explained a sprained ankle by telling people that he had fallen off his wallet?

*

Dept. of Awful Implication. "Since the DC-8 was specifically designed with a growth potential, we can foresee a future model with an attractive earning capability for operators."—*J. R. McGowen, a Douglas vice-president.*

*

by Gren

Industry Record

Plastics Production

Saro Products, Ltd., of Whippingham, East Cowes, Isle of Wight, have reported that the Plastics Division of their Folly Works was completely unaffected by the fire which damaged other departments on January 21-22. The production of Saroy extruded thermoplastics sheet was uninterrupted. Indeed the output of this material is being substantially increased by the use of new plant which has recently been installed.

Australian Fueller

A new 8,000-gallon capacity aircraft fuelling unit, the first of its type to be built in Australia, has been placed in service by BP (Australia), Ltd. The vehicle consists of a six-wheeled Leyland Hippo truck chassis hauling a six-wheeled trailer. It is designed primarily for underwing pressure fuelling of jet aircraft and has been called the Air BP "Yarra."

The tanks on the fueller were built from aluminium alloy by Cromac Pty., Ltd., of Melbourne. The Hippo carries a 4,000-gallon tank divided into two compartments of 2,400 and 1,600 gallons, and the trailer carries a single compartment tank of 4,000 gallons capacity.

Situated between the Hippo's cab and tank is the pumping compartment which houses a centrifugal pump and pressure control valve. From here onwards the fuel flow divides into two separate delivery systems, each comprising a micro-filter, air eliminator, pre-setting flow meter and hose reel. All the controls and instruments used when fuelling are conveniently grouped in this compartment.

The pump is driven from a special engine power take-off and the Leyland can deliver to the aircraft more than 400 gallons of aviation turbo kerosene a minute. The hose reels are wound and unwound by hydraulic drive and the tank compartment valves are operated by air pressure.

The "Yarra" 8,000-gallon capacity fueller in service with BP in Australia. It is primarily designed for underwing fuelling of jet aircraft.

Combined Power Unit

A mobile ground support unit supplying both pneumatic and electrical power has been developed jointly by the Boeing Industrial Products Division and the General Electric Co., of America. The unit is an adaptation of the Boeing Turbo-Starter, a panel truck equipped with a compressor driven by a gas-turbine, to supply air for starting of commercial turbojet transports and other ground support applications such as maintenance and servicing.

The new unit, in addition to the turbine compressor, carries a General Electric 50 kWA., 400-cycle alternator. It is capable of supplying electrical power and pneumatic starting power simultaneously, and is powered by a Ford V-8 engine which also drives the alternator.

Middle East Service

The International Division of Collins Radio Co. is to open an office at Beirut, Lebanon, serving the Middle East and Africa. Charles Wallach, a former F.A.A. technical representative in Lebanon, will head the new office, which will open in March and cover an area including Lebanon, Jordan, the United Arab Republic, Iran, Libya, Tunisia, Turkey/Cyprus, Syria, Pakistan, Aden, Saudi Arabia, Arabia-Kuwait and Africa (with the exception of Morocco and Algeria). This area was formerly served by Collins' Geneva office.

Outstanding Castings

The British Steel Founders' Association, Sheffield, is showing a collection of more than 50 outstanding castings at the Engineering Materials and Design Exhibition, opening at Earls Court, London, on February 22. The steel foundry industry hopes that it will demonstrate that there are now considerable facilities in this country for the economic production of components of all types for a wide variety of industrial purposes.

As recorded on this page, one of the B.S.F.A. examples of precision castings at a forthcoming exhibition is this hinge pivot. Forming part of the elevating frame for launching guided missiles, it is produced by Samuel Osborn and Co., Ltd.

Examples which will be on display, either by actual casting or photographs, include an aircraft casting by APV-Paramount, Ltd.; and a cast hinge pivot, which forms part of the elevating frame for launching guided missiles, by Samuel Osborn and Co., Ltd. They have been selected to show how steel castings have actually replaced components previously fabricated or forged.

At the same time, this development has enabled designers using steel castings to introduce strength, or lightness, as well as allowing redesigning to take place. The various displays will also spotlight how the problems of thermal and mechanical shock, wear or distortion have been successfully countered in this process.

Tinting and Colouring

A considerable amount of research work has been undertaken on fluorescent finishes with a view to increasing the durability, and consequently the effectiveness, of these materials for longer periods. The latest development in this field by Docker Brothers is Dockerblaze fluorescent paint, which maintains its high degree of brightness for periods well in excess of 12 months.

Dockerblaze has been developed for application to any surface, not only on

The new Boeing Turbo-Starter vehicle developed jointly by the company's Industrial Products Division and the General Electric Co., of America. It is an adaptation of the earlier Boeing Turbo-Starter now in general service.

Industry Record . . . .

aircraft, both on metal and supported fabric, but for marking danger points, emergency exits, signs, fire points, fire and breakdown vehicles, and on any article which is required to stand out from its surroundings. It has a high degree of resistance to ester-based lubricants, kerosene, mineral oils, water-methanol mixtures and de-icing fluid.

It can be released as conforming with A.R.B. requirements, as a proprietary material, pending the issue of a specification. The colour range consists of rocker red, blaze orange, signal green and saturn yellow.

Another new Docker Brothers' material is Fibrecolor, used for tinting polyester laminates for the aircraft industry. It renders the laminate fireproof; tests show that the resultant laminate meets the A.R.B. requirements on inflammability. It can be supplied in a large range of colours, and instructions for its use and all information are available on request.

Another development is the introduction of Fibreblaze for colouring polyester laminates, to give a fluorescent finish. It is available in four colours.

G.E.C. Move

The publicity organization of The General Electric Co., Ltd., has moved from Magnet House, Kingsway, to Kemble House, Kean Street, London, W.C.2. The telephone number, TEM 8000, remains the same.

Apprentice Training

A conference on "Training the Apprentice" was organized by the Training Within Industry Association at Caxton Hall, Westminster, on February 11. One of the four speakers was Mr. A. R. Essex, who is in charge of training at E. K. Cole, Ltd. He spoke on "Improving the Training Between Craftsman and Apprentice." The conference was attended by members of the Association from London and the South-East.

Helvin Grommets

Hellermann, Ltd., of Crawley, Sussex, has produced a new catalogue on its Helvin grommets. Copies are available from the company on request.

Oxygen Mask Development

Among the many problems associated with high-altitude flying is that of designing suitable oxygen masks for aircraft personnel. In this connection, Airmed, Ltd., of Harlow, Essex, has recently developed a chain toggle for use with the latest R.A.F. pressure breathing mask. The chain toggle device is mounted on an exo-skeleton fabricated from glass-fibre reinforced Bakelite polyester resin.

The chain toggle arrangement was made at the instigation of the Institute of Aviation Medicine, Farnborough. Reinforced resin was chosen for the exo-skeleton because it combined sufficient strength, lightness in weight, and freedom from distortion when subjected to high altitudes and low temperatures.

The strength of the exo-skeleton enables it to be used as a platform upon which a chain toggle harness can be firmly mounted for retaining the mask to the helmet. Another advantage in using reinforced resin for this work is that the component, in spite of the complex shape, can be fabricated with comparative simplicity in low-cost moulds.

Publications Received

British Engineers' Cutting Tools.—Guide to Buyers. Issued by the National Federation of Engineers' Tool Manufacturers. 72 pp.; 5½ in. by 3¾ in. Loxley Bros., Ltd. Price 5s.

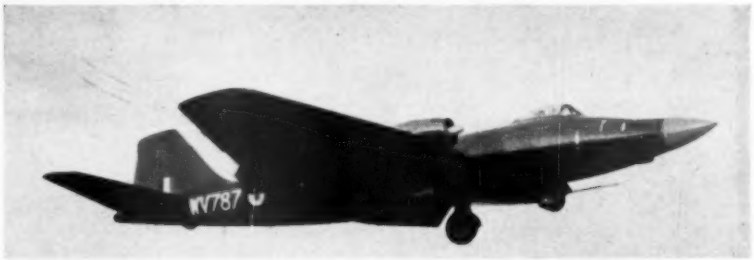
Electronic Flash Photography.—By Ralph L. Aspden. 192 pp.; 5½ in. by 8½ in. Illustrated. Temple Press Limited. Price 37s. 6d.

Foundations of Aerodynamics, Second Edition. By A. M. Keuthe and J. D. Schetzer. 446 pp.; 6 in. by 9¼ in. Illustrated. Chapman and Hall, Ltd. Price 94s.

Radar-Bibliography.—Radar literature of the past five years. By W. Reinhardt. 103 pp.; 8¼ in. by 11¾ in. Westdeutscher Verlag/Köln and Opladen. Price DM.26.80.

Satellites and Scientific Research.—By Desmond King-Hele. 180 pp.; 5½ in. by 8¾ in. Illustrated. Routledge & Kegan Paul, Ltd. Price 21.

Who's Who in the Motor Industry, Fourth Edition. Published in association with *The Motor* and *The Commercial Motor*. 592 pp.; 5¾ in. by 8¾ in. Temple Press Limited. Price 42s.



A Canberra B (I) 8 with a distinctive new radar installation in the nose. It is being operated by Ferranti, Ltd., at R.A.F. Turnhouse, Edinburgh, who are developing radar equipment for the NA.39 Naval strike aircraft.

Aviation Calendar

February 12.—R.Ae.S. Agricultural Aviation Group lecture, "Choice of Aerial Vehicle," by N. D. Norman and T. Clutterbuck, in the Library, 4 Hamilton Place, **London,** W.1, at 19.00 hrs.

February 15.—R.Ae.S. Derby Branch lecture, "The Use of Rockets in Scientific Research," by Prof. H. S. W. Massey, at Rolls-Royce Welfare Hall, Nightingale Road, **Derby,** at 18.15 hrs.

February 15.—R.Ae.S. Halton Branch lecture, "Parachutes," by S. B. Jackson, at the Branch H.Q., R.A.F. **Halton,** at 18.45 hrs.

February 16.—Royal Technical College lecture, "Propulsion of Space Vehicles," by E. G. D. Andrews, at the Royal Technical College, **Salford,** at 19.00 hrs.

February 16.—R.Ae.S. Glasgow Branch Pilcher Memorial lecture, "History of Development of Airlines in Scotland," by Capt. E. A. Starling, at the Royal College of Science and Technology, **Glasgow,** at 19.15 hrs.

February 17.—R.Ae.S. Weybridge Branch lecture, "Supersonic Transport," by P. A. Hufton, at the Apprentice Training School, Vickers-Armstrongs, **Weybridge,** at 18.10 hrs.

February 17.—R.Ae.S. Bristol Branch lecture, "Firestreak," by G. H. F. Brown, in the Conference Room, Filton House, **Bristol,** at 18.00 hrs.

February 17.—R.Ae.S. Preston Branch lecture, "The Application of Special Purpose Machine Tools," by I. T. Clowes, at the R.A.F.A. Hall, **Preston,** at 19.30 hrs.

February 18.—R.Ae.S. Astronautics and Guided Flight Section lecture, "Missile Control Problems," by D. Best, at the Institution of Mechanical Engineers, Birdcage Walk, **London,** S.W.1, at 18.00 hrs.

February 19.—Institute of Navigation lecture, "Space Navigation," by Dr. J. G. Porter, at The Royal Geographical Society, 1 Kensington Gore, **London,** S.W.7, at 17.15 hrs.

February 19.—R.Ae.S. Birmingham and Wolverhampton Branch lecture, "The Rolls-Royce Tyne Engine," by D. Maclean, at the Engineering Centre, **Birmingham,** at 19.30 hrs.

Company Notices

NEW COMPANIES

Timken, Ltd. (646,894).—Private co. Reg. January 13. Cap. £100 in £1 shares. Objects: To carry on the business of manufacturers of and dealers in tapered roller bearings, etc. Subscribers (each with one share): Simon MacLachan and Jeremy P. Raisman, 11 Old Jewry, E.C.2, solicitors. First directors are not named. Sols.: Clifford-Turner and Co., 11 Old Jewry, E.C.2.

Shipping Ventures, Ltd. (647,002).—Private co. Reg. January 14. Cap. £1,000 in £1 shares. Objects: To purchase, charter, hire, operate and maintain ships and aircraft, etc. Subscribers (each with one share): J. B. A. Willis, 18 Austin Friars, E.C.2 (solicitor); D. W. Dare, 18 Austin Friars, E.C.2 (solicitor). First directors are not named. Sols.: Slaughter and May, 18 Austin Friars, E.C.2.

H. J. Pratt (Engineering), Ltd. (647,268).—Private co. Reg. January 18. Cap. £3,000 in £1 shares. Objects: To carry on the business of general, precision, mechanical, motor, aeronautical and electrical engineers, etc. Directors: Herbert J. Pratt and Mrs. Kathleen R. Pratt, both of The Crossways, Dorchester-on-Thames, Oxon. Sec.: Herbert J. Pratt. Reg. office: The Forge, Dorchester-on-Thames, Oxon.

Sahlin Automation, Ltd. (647,456).—Private co. Reg. January 20. Cap. £10,000 in £1 shares. Objects: To carry on the business of manufacturers of and dealers in machine tools and automation devices, including devices for the production of machinery, vehicles, ships, aircraft, and equipment, etc. Directors: Richard T. Sahlin, Bloomfield Hills, Mich., U.S.A.; Harry J. Tiffany, jnr., Rochester, Mich., U.S.A.; John W. DeLind, jnr., Clarkston, Mich., U.S.A.; Frederick H. Gardner, 25 St. Saviours Crescent, Luton, Beds; Eugene Byrne, 11 Cambridge Road, S.W. Sec.: G. J. Howe. Sols.: Crane and Hawkins, W.C.2. Reg. office: 31-45 Gresham Street, E.C.2.

Personal Notices

BIRTHS

Baldwin.—On January 25, at Joseph Fraser Memorial Nursing Home in Colombo, Ceylon, to Mary (*née* Bartlett), wife of Sqn. Ldr. Alan F. Baldwin—a daughter.

Greenslade.—On January 25, at R.A.F. H'y, to Mary (*née* Churchard), wife of Flt. Lt. D. W. Greenslade, M.B.E., A.F.C., R.A.F.—twin girls.

Holland.—On January 28, at R.A.F. Hospital, Wegburg, to Joan, wife of Flt. Lt. John Holland—a daughter.

Mills.—On January 29, at R.A.F. Hospital, Changi, Singapore, to Pamela (*née* Jones), wife of Flt. Lt. N. H. Mills, R.A.F.M.S.—a daughter.

Nugent.—On January 31, at the Royal United Hospital, Bath, to Diana (*née* Burnett), wife of Flt. Lt. N. A. D. Nugent—a daughter.

Parker.—On January 28, at 11 Albert Road, Watford, Herts, to Diana, wife of Flg. Off. W. D. Parker—a son.

Picking.—On January 27, at Farley House, Farnborough, to Ann (*née* Carlile), wife of Flt. Lt. A. W. Picking—a son.

Tuffin.—On January 27, at R.A.F. Hospital, Nocton, Lincs, to Dorothy (*née* Chubb), wife of Flt. Lt. R. Tuffin—a son.

DEATH

Rowbotham.—On February 1, Allan John Rowbotham, R.F.C., R.A.F.

PIONEER IN AFRICA. These Twin Pioneers are part of No. 21 Squadron, R.A.F., now out in East Africa. Specifically designed for liaison work, they do a score of jobs that a larger or faster aircraft could not tackle. One day they will fly supplies to a famine-stricken village. Next day, the job will be flying troops to a 400-yard airstrip, or photographing the country for a new survey. Or reconnaissance, or dropping a doctor by parachute to an urgent case.

'Flight' Photograph

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Battle of Britain veterans often talk about the old Spitfire days. Looking at today's sleek jets you might think that sort of flying had vanished for ever. Not a bit of it! All over the world, there's still plenty of what veterans call 'real flying'. And this will always go on in the Royal Air Force. Take the job of carrying in supplies; or flying out hospital cases; or search and rescue. The truth is that in the R.A.F. you've got to be able to handle many types of aircraft. Standards today for R.A.F. aircrew are higher than ever they've been. But if you are good enough, you'll lead a life any man might envy. Why not find out more?

The R.A.F. wants Pilots, Navigators and Air Electronics Officers. For details of how to apply, of pay, conditions and allowances, write to Group Captain J. N. Ogle, A.F.C., A.F.M., Air Ministry (AP35a), Adastral House, London, WC1. (Applicants must be between 17½ and their 26th birthday and have gained a good G.C.E. or equivalent.)

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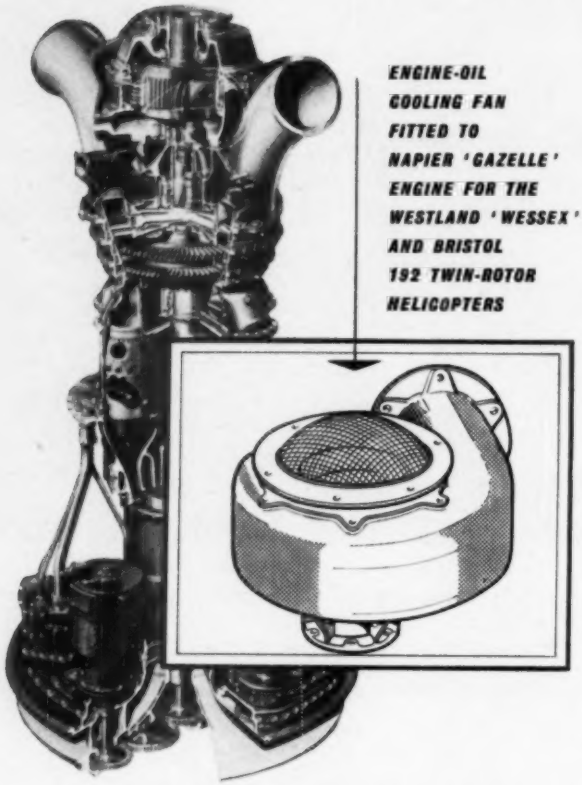

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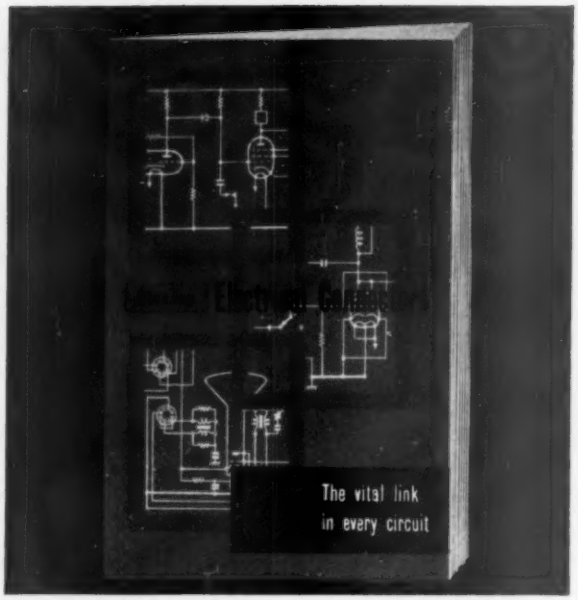

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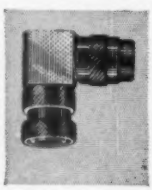

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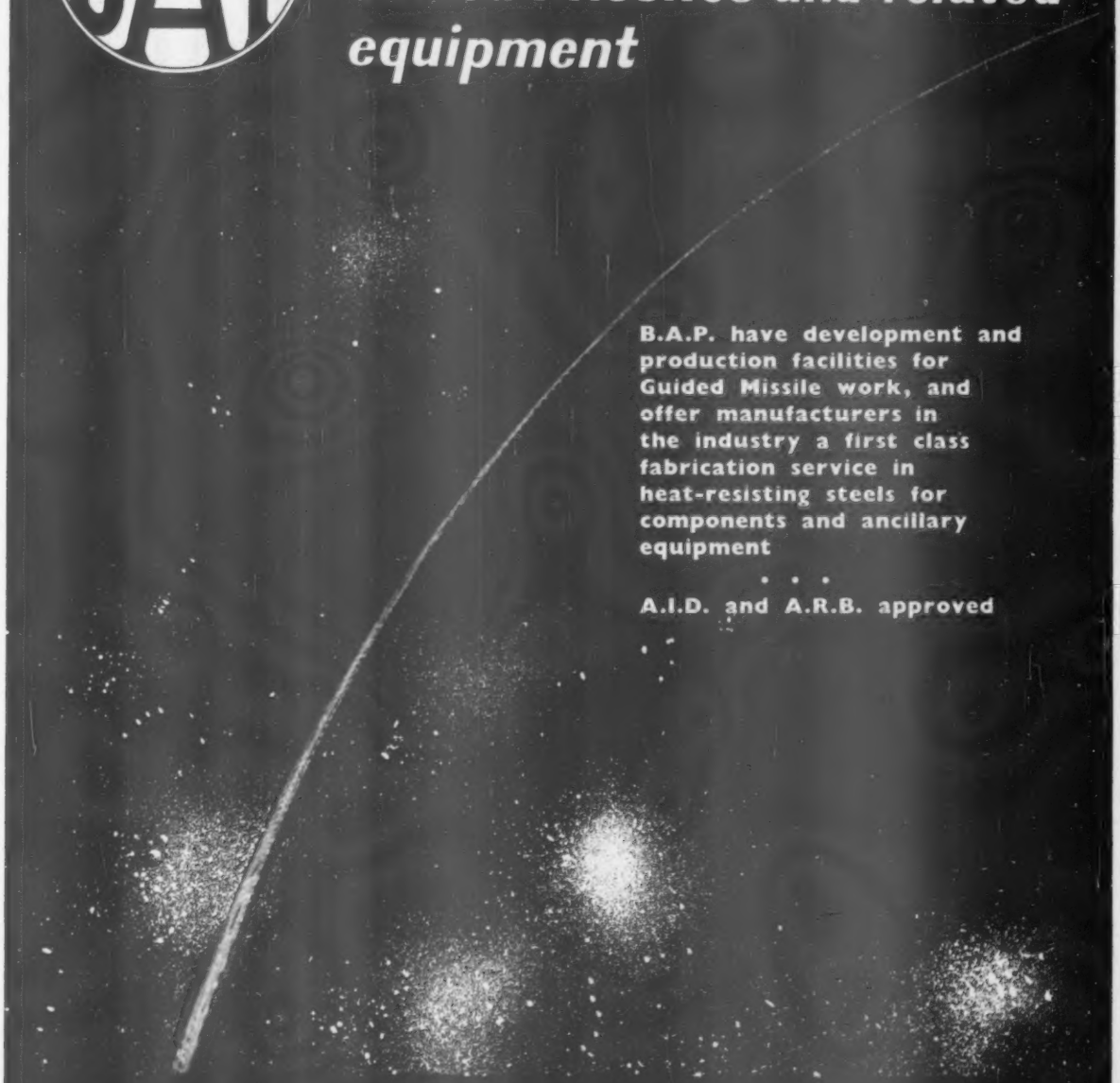

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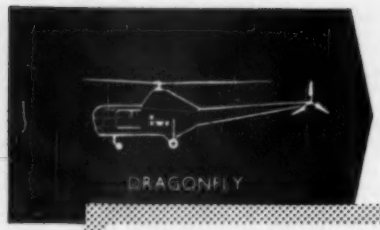

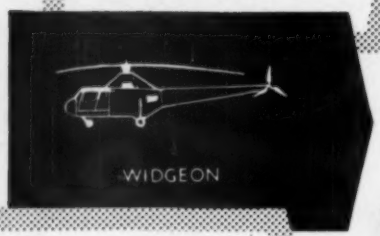

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NOTICES

AIR TRANSPORT ADVISORY COUNCIL

THE AIR TRANSPORT ADVISORY COUNCIL give notice that they have received the undermentioned applications to operate scheduled air services:—

FROM BRITISH OVERSEAS AIRWAYS CORPORATION, OF LONDON AIRPORT, HOUNSLOW, MIDDLESEX:—

APPLICATION NO. 3389 for permission to include an optional traffic stop at Toronto on their Reserved Route No. 18: London-Manchester (opt.)-Prestwick or Shannon-Keflavik and/or Gander-Montreal-Detroit (opt.)-Chicago (opt.).

FROM AIRWORK LTD., OF 35 PICCADILLY, LONDON, W.1:—

APPLICATION NO. 1462/4 for permission to include an optional traffic stop at Robertsfield on the Normal Scheduled Service which they are at present authorized to operate with Viscount aircraft, on the route London Airport or Gatwick-Lisbon-Las Palmas - Dakar - Bathurst - Freetown - Takoradi (opt.)-Accra, at a frequency of two return flights each 28 days until December 31, 1967.

FROM HUNTING-CLAN AIR TRANSPORT, LTD., OF LONDON AIRPORT, HOUNSLOW, MIDDLESEX:—

APPLICATION NO. 1456-4 for permission to include an optional traffic stop at Robertsfield on the Normal Scheduled Service which they are at present authorized to operate with Viscount aircraft on the route London-Lisbon-Las Palmas-Dakar-Bathurst-Freetown-Takoradi (opt.)-Accra, at a frequency of two return flights each 28 days, until December 31, 1967.

These applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on July 30, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3 Ipean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. 521-13

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ASSISTANT experimental officer for R.N. Engineering College, Manadon, Plymouth. Unestablished post for duty as demonstrator in department of Aerodynamics and Aircraft Structures, to supervise wind tunnel and aircraft structural tests. Applicants should be of Inter.B.Sc., H.N.C. or equivalent standard; theoretical qualifications in aerodynamics, wind tunnel and structural testing desirable.
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APPLICATION forms obtainable from Commanding Officer, R.N. Engineering College, Manadon, Plymouth, should be returned by February 27, 1960. 521-15

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Closing date March 4, 1960. 521-8

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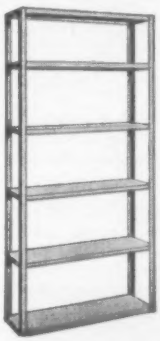

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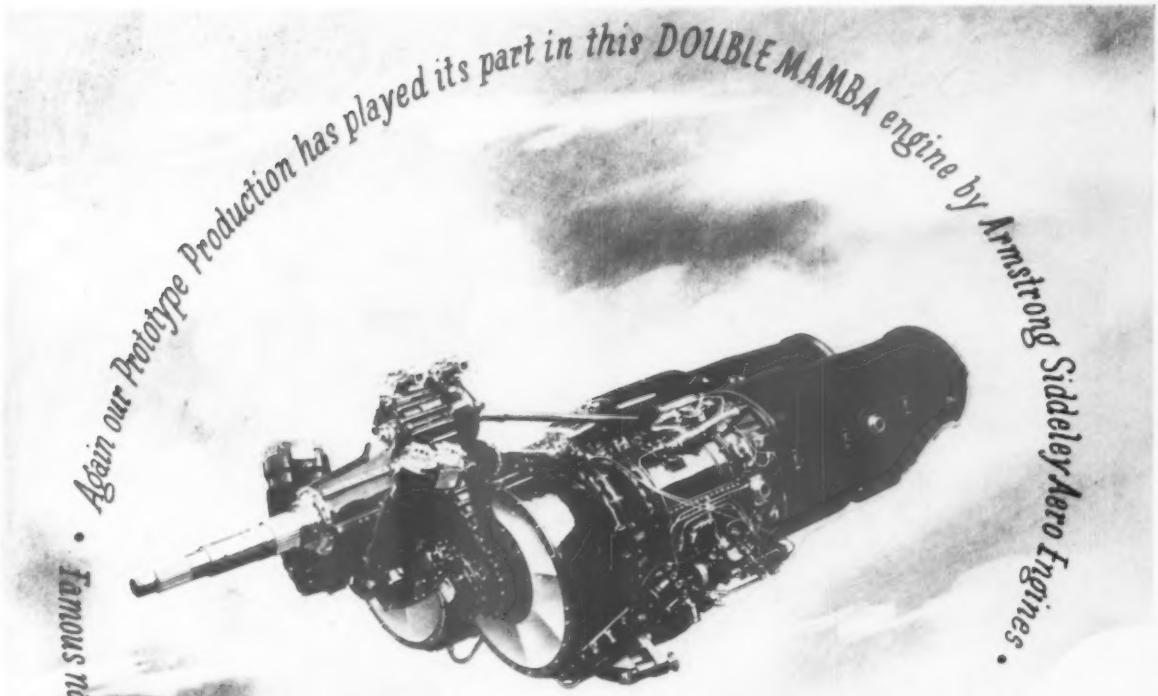
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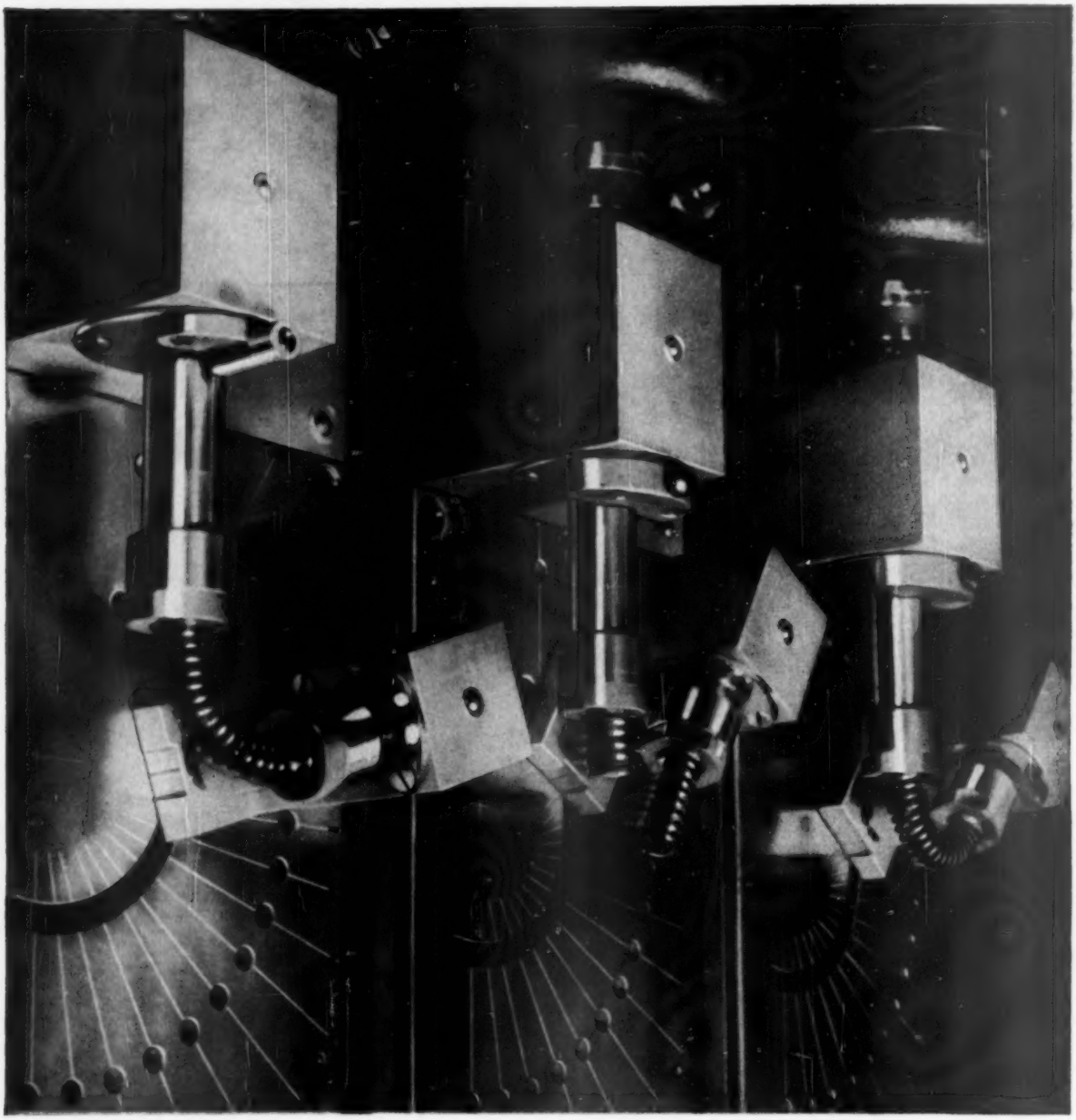

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